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HAEMATOLOGY OF THE CAMELIDAE

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Aside from the common misinformation that the red cell of the camel is oval and nucleated, there is surprisingly little known concerning the haematology of the Camelidae. Gulliver (1875) gives the diameter of their dried red cells. Bottcher (1877) describes the erythrocytes as being nucleated. Ponder (1924) lists red cell counts and measurements for various species, and also points out that there is no evidence for Bottcher's statement that the camel red cells are nucleated. Concerning the white cells there is no reliable information available.

The purpose of this study is to give concisely and yet with sufficient detail the haematology of the Camelidae (which includes the camels and "cameloids"). In all cases the blood was taken into oxalate from a neck vein of healthy animals kept under the ordinary conditions of captivity. The examination of the cells was commenced within one hour from the time of withdrawing the blood.

Unless otherwise stated, the following descriptions and differential counts are based on blood films prepared by the smear method stained with Wright's blood-stain. The red cell counts were made in the usual way, using Hayem's solution. Triplicate counts were made and the average result per cubic millimetre is given. The white cell counts were obtained in a similar way, using a solution of acetic acid for dilution. The haemoglobin was estimated as carboxy-haemoglobin by Palmer's colorimetric method, with the blood of one of us (H. A. C.) as a standard (100 per cent). These readings were made in triplicate and the average determined. The polynuclear counts were made in the manner described by Cooke (1914), and on 100 cells. The stain employed was iron haematoxylin, but counts can also be made on films stained with Wright's or Giemsa's stain. The method used for determining the resistance

* The first of a series of researches undertaken by a coöperative arrangement between the Department of Biology of New York University and the New York Zoological Society.

of the red cells to haemolysins has been adequately described by Ponder (1927) and Yeager (1928), while the technique for studying the dimensions of the red cells has also been given in full by Ponder and Millar (1924).

I. Llama glama

a—The red cells, when seen in the fresh state in plasma, have the appearance of flattened ellipsoids, with a perfectly regular outline and homogeneous structure. The erythrocytes do not form typical rouleaux, but remain in contact with one another so as to form 'chains,' one end of one cell overlapping the end of the cell next to it, and so on.

In stained films the red cells appear smaller than in the fresh state, but retain their shape remarkably well. Measurements of the length and breadth of these cells in the fresh and dried preparations show a definite change in size on drying.

Fresh red cells in plasma—Length 7.8 μ. Breadth 4.3 μ.

Red cells in dried films—Length 7.2 μ. Breadth 3.9 μ.

When the erythrocytes are fixed in methyl alcohol, the haemoglobin is especially deposited in the central parts of the cell, and as a result the central area takes on a deeper stain than the peripheral region. This appearance may possibly be responsible for the erroneous statement which has sometimes been made that the cells are nucleated.

b—The average haemoglobin percentage is 89 per cent.

c—Red cell count (cells per cubic millimetre)—11,300,000.

d—White cell count (cells per cubic millimetre)—10,300.

e—The morphology of the white cells of a young specimen shows no outstanding difference as compared to that of the adult. It may be noted, however, that the blood of young animal stains more rapidly and gives a better differentiation than that of the adult.

1—The polymorphonuclear neutrophilic leucocytes (P. M. N.) are approximately circular and range in size from 10 to 12 μ. The nucleus is quite irregular in form, showing the familiar lobations of polymorphs in general. The cytoplasm is slightly acidophilic in reaction and studded with many fine granules which are neutrophilic and which stain a lilac color in some cells and pink in others.

2—The polymorphonuclear eosinophiles (P. M. E.) are circular or slightly oval in shape and fairly constant in size, 10 μ. Their nucleus is similar to that of the neutrophile just described, but stains less intensely. The cytoplasm, which stains a very light blue and is hardly distinguishable, is practically filled with coarse bright red granules.

3—The polymorphonuclear basophilic leucocytes (P. M. B.) are fairly circular in outline, and are the smallest of the polymorphonuclear leucocytes, 8 μ. The nucleus which occupies the greater part of the cell is difficult to differentiate since it is basophilic in staining quality and takes a blue-purple color slightly less intense than that of the coarse granules which fill the cytoplasm.

4—The lymphocytes (L.) are more circular than any of the other blood elements and range in size from 8 to 10 μ. The nucleus is circular or slightly ovoid in outline, stains a deep blue, and fairly fills the cell, leaving a variable margin of faint sky-blue tinted cytoplasm. Occasionally a few scattered azure granules of variable size may be seen.

5—The large mononuclear leukocytes (L. M.) are variable in outline from perfect circles to irregular ovals. They average approximately 12 μ in size. The eccentrically-placed nucleus stains deep blue, yet several shades lighter than that of the lymphocytes, and presents a slight indentation on the side toward the larger area of cytoplasm. The cytoplasm which stains a light blue similar to that of the lymphocytes invariably contains a goodly number of coarse, azure granules.

6—The transitional leukocytes (T.) are large ovoid cells ranging from 10 to 12 μ in size. The nucleus appears eccentrically placed and deeeply notched, and stains similar to that of the polymorphocuclear leukocyte. The cytoplasm stains a light blue and contains a large number of neutrophilic granules which tend to be concentrated and more deeply stained in the notch of the nucleus. It is difficult to distinguish these cells from the Class I polynuclear neutrophilic leucocytes.

f The differential count as determined by classifying the cells according to the description just given is:

P. M. N.	63	L.	11
P. M. E.	10	L. M.	4
P. M. B.	10	T.	2

g—The polynuclear count for this animal is very much the same as in man and rabbit.

	I	II	III	IV	V
L. glama	14	29	40	13	4

h Resistance of red cells to haemolysins.

1 The resistance to saponin was found to be 0.75 times as great as in man.

2 The resistance to sodium taurocholate is 1.20 times as great as in man.

3 The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which haemolyze at 0.32 per cent saline.

II. Llama pocas

a—The general morphology of the red cells of *Llama pocas* is essentially the same as that of *Llama glama*. The measurements are slightly different, and are given merely as a matter of record.

Fresh red cells in plasma—Length 8.0 μ. Breadth 4.3 μ.

Red cells in dried film—Length 7.6 μ. Breadth 4.1 μ.

b—Haemoglobin, 106 per cent.

c—Red cell count, 19,400,000.

d—White cell count, 12,100.

e—The general morphology of the blood elements are so much alike that for the sake of brevity the description given for *Llama glama* is adequate for

Llama pocas. The following brief note on each type of cell will therefore be limited to those differences deemed of note.

1—The polymorphonuclear neutrophilic leukocytes (P. M. N.) vary in size from 8 to 10 μ. The neutrophilic granules are regularly placed and somewhat coarser than ordinarily. Both the granules and cytoplasm stain poorly and in a large number of cells are decidedly chromophobic.

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are approximately 8 to 9 μ in diameter, irregularly oval in outline and heavily studded with large bright red granules.

3—The polymorphonuclear basophilic leukocytes (P. M. B.) are surprisingly frequent in occurrence. They are approximately circular in outline and 4 to 5 μ in diameter. It is impossible to differentiate the nucleus which is practically lost in the heavy deeply staining basophilic granules which fill the cytoplasm.

4—The lymphocytes (L.) are definitely circular in outline and 6 to 8 μ in diameter. The nucleus is centrally located, leaving a narrow border of clear blue cytoplasm. No azure granules were observed.

5—The large nomonuclear leukocytes (L. M.) average 10 μ in diameter. The eccentrically placed, notched nucleus stains the same as that of the lymphocytes.

6—The transitional leukocytes (T.) range from 10 to 12 μ in size. The neutrophilic granules of the cytoplasm, as well as the cytoplasm itself, stains well, and therefore can be used as a differential for distinguishing between this type of cell and a Class I polynuclear neutrophilic leukocyte.

f—Differential Count: –

P. M. N.	51	L.	4
P. M. E.	5	L. M.	2
P. M. B.	37	T.	1

g—Polynuclear Count:-

	I	II	III	IV	V
Llama pocas	22	31	37	8	2

h—Resistance to haemolysins:—

1—The resistance to saponin was found to be 1.00 times as great as in man.

2—The resistance to sodium taurocholate is 1.90 times as great as in man.

3—The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which just haemolyze at 0.32 per cent saline.

III. Camelus dromedarius

a—With the exception of the slight difference in size the red cells of this animal are very similar to those of *L. glama* and need no further description.

Red cells sizes:—

Fresh red cells in plasma—Length 8.0 μ. Breadth 4.6 μ.

Red cells in dried film—Length 7.1 μ. Breadth 4.1 μ.

b—Haemoglobin, 96 per cent.

c—Red cell count, 10,800,000 per c. mm.

d—White cell count, 12,000 per c. mm.

e—With the exception of the differences in size the cells of this animal are so similar to those of *Llama glama* that the morphological description given in part one can be applied to the various cellular elements of this blood.

1– The polymorphonuclear neutrophilic leukocytes (P. M. N.) are fairly constant in size, 13 μ.

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are comparatively numerous. The coarse granules which fill the cytoplasm stain a deep pink rather than the characteristic bright red, and the cell shows an irregular ragged outline. Their size is roughly 11 μ.

3–The polymorphonuclear basophilic leukocytes (P. M. B.) are 10 μ in diameter. The coarse granules which fill the cytoplasm seem to stain more intensely at the periphery of the cytoplasm where they appear almost blue black in contrast to the definite deep purple of the other granules closer to the nucleus.

4—The lymphocytes, (L.) which are approximately 8 μ in diameter, have a very thin cytoplasmic rim which stains the usual sky-blue. In some cases the deep blue nucleus appears to fill the cell completely and no cytoplasmic rim can be differentiated.

5—The arge mononuclear leukocytes (L. M.) average about 13 μ in size and show light blue staining granules in the cytoplasm rather than the azure granules as usually described.

6 - The transitional leukocytes (T.) are easily recognized because of their size, 15 μ. The eccentrically placed indented nucleus, however, is not proportionately as large and as a result there is a good deal of cytoplasm to be seen. The fine neutrophilic granules are sparsely scattered throughout the cell.

f Differential Count.

P. M. N.	55	L	8
P. M. E.	27	L. M.	6
P. M. B.	3	T.	1

g Polynuclear Count:

	I	II	III	IV	V
C. dromedarius	24	35	32	7	2

h Resistance to haemolysins:–

1—The resistance to saponin was found to be 1.03 times as great as in man.

2–The resistance to sodium taurocholate is 1.72 times as great as in man.

3–The red cells were found to be resistant to 0.28 per cent saline which is a decidedly greater resistance than is shown by human erythrocytes which just haemolyze at 0.32 per cent. saline.

IV. *Camelus batriens*

a—The red cells of this species are sufficiently similar to those of *L. glama* as to warrant no descriptions other than a notation of their sizes.

Fresh red cells in plasma—Length 8.1 μ. Breadth 4.5 μ.

Red cells in dried film—Length 7.5 μ. Breadth 3.6 μ.

b—Haemoglobin, 87 per cent.

c—Red cell count, 10,450,000.

d—White cell count, 10,800.

e—There is no marked difference in the staining quality or morphology of the blood elements of the young animal as compared to that of the adult. The leukocytes of this species of camel are larger and better differentiated than those of the other species studied in this group.

1—The polymorphonuclear neutrophilic leukocytes (P. M. N.) are irregular in outline tending more toward the circular than the oval in shape. Their approximate mean diameter is fairly constant, measuring approximately 16 μ. The nucleus which is typically polymorphous stains a light reddish purple. The cytoplasm which is clear and very slightly tinted a light blue contains various sized evenly stained neutrophilic granules.

2—The polymorphonuclear eosinophilic leukocytes (P. M. E.) are typical. They measure approximately 12 to 14 μ in diameter.

3—The polymorphonuclear basophilic leukocytes (P. M. B.) are circular in outline with an irregular incompletely lobed nucleus which stains a reddish purple, making it easily distinguishable from the light blue cytoplasm thickly packed with coarse deep blue or purple stained granules. These cells measure about 8 to 10 μ.

4—The lymphocytes (L.) vary in size from 12 to 16 μ and contain a large deep blue staining nucleus which is slightly eccentric in position. The irregular rim of cytoplasm stains the typical sky-blue.

5—The large mononuclear leukocytes (L. M.) are irregularly circular in outline. The nucleus which is large and deeply indented stains a reddish purple. The sky-blue cytoplasm contains many azure granules clumped, as usual, in the indentation of the nucleus. These cells are rather constant in size, measuring about 22 μ.

6—The transitional leukocytes (T.) contain a deep blue staining nucleus in a pink colored cytoplasm which is filled with typical neutrophilic granules. These cells are very large, averaging approximately 30 μ in diameter.

f—Differential Count:—

Adult	P. M. N.	67	L.	11
	P. M. E.	15	L. M.	3
	P. M. B.	2	T.	2

g—Polynuclear Count:—

	I	II	III	IV	V
C. batriens	23	36	34	6	1

h—Resistance to haemolysins:—

1—The resistance to saponin was found to be 0.96 times as great as in man.

2—The resistance to sodium taurocholate is 1.42 times as great as in man.

3—The red cells were found to be resistant to 0.26 per cent NaCl, which

is a decidedly greater resistance than is shown by human erythrocytes which haemolyze at 0.32 per cent saline.

It cannot be expected, of course, that the examination of the necessarily few specimens of each species will provide us with perfectly trustworthy information, for allowance has to be made for individual variations; we believe, however, that the data presented is both more representative and more trustworthy than any at present existing.

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(A fuller account of these investigations will be found in the following paper:—

Studies in Comparative Haematology. I. Camelidae. Quarterly Journal of Experimental Physiology, vol. xix.)

HAEMATOLOGY OF THE PRIMATES

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While occasional references may be found regarding the red cell counts and the differential counts of certain primates, these are usually secondary matters arising in connection with some research problem. Aside from the work of Gulliver (1875), which concerns itself with the red cell sizes alone, there is no single investigation dealing primarily with the haematology of the primates. The present study has been undertaken with a view to fulfilling the need for this particular investigation.

The blood of the monkeys is best obtained from a marginal ear vein. The ear is first shaved and rubbed with ether or benzene; a prominent vein near the margin of the ear is then opened with a single cut with a razor blade. Much of the difficulty which may be experienced in controlling adult specimens of the larger primates may be avoided by using young animals, but the difficulty is not as a rule great if the animal is held by a keeper with whom it is familiar.

With the exception of the blood of the spider monkeys, the dilutions for the red blood cell count, white blood cell count, haemoglobin determination, and occasionally for the suspensions for haemolysis, were made from fresh unoxalated blood. The smears for the differential counts and polynuclear counts were obtained at the same time. The blood of the spider monkeys was collected into oxalate in the usual proportions. Owing to the difficulty which we have experienced in obtaining more than quite small quantities of blood from many of the monkeys, a modification has been introduced in the method of preparing the films of cells for measurement. A small volume of blood is drawn into a capillary pipette, which is then sealed at both ends. When the preparation of red cells is made for photography, the seals are removed and the contents of the tube, consisting of serum and clot, expelled on to the surface of a slide. The clot is removed with a pair of fine forceps, and the remaining serum covered with a coverslip. The

* The second of a series of researches undertaken by a coöperative arrangement between the Department of Biology of New York University and the New York Zoological Society

serum always contains a considerable number of cells, which can be photographed and measured in the usual manner. Under these conditions the cells are measured in serum instead of in oxalated plasma, but this does not affect their mean diameter.

Except where otherwise stated, the technique employed is identical with that described in the first paper of this series (Haematology of the Camelidae). It should also be mentioned that the general morphology of the leucocytes of the primates examined in this investigation is so much like that of the leucocytes of man that differences alone are described.

I. Gorilla gorilla

a—The red cells are typical biconcave discs similar to the red cells of man. Their mean diameter, however, is slightly smaller. Cells in plasma have a mean diameter of 7.7 μ, while cells in dried films have a diameter of 7.3 μ.

b—The average haemoglobin percentage is 83 per cent.

c—Red cell count per cubic millimetre, 6,250,000.

d—White cell count per cubic millimetre, 6,800.

e—The morphology of the cells presents several points of interest.

1—The polymorphonuclear neutrophiles (P. M. N.) are circular in outline and range in size from 9 to 12 μ. There appears to be a predominance of bilobed cells. The cytoplasm, granules, and nucleus are typical.

2—The polymorphonuclear eosinophiles (P. M. E.) measure approximately 11 μ. The deep red granules are evenly distributed throughout the light blue cytoplasm. The nucleus stains less intensely than that of the neutrophiles.

3—The polymorphonuclear basophiles (P. M. B.) are circular and measure about 10 μ. The nucleus is obscured by the coarse basophilic granules. The cell has the appearance of a compact mass of chromatin with minute chromophobic areas.

4—The lymphocytes (L) are the smallest of the white cells, and measure only 8 μ. The nucleus is irregular and practically fills the cell.

5—The large mononuclears (L. M.) are variable in outline from perfect circles to irregular ovals. They measure about 16 μ. The eccentrically placed nucleus stains a deep blue. There are a very few coarse azure granules scattered throughout the cytoplasm.

6—The transitional leucocytes (T) closely resemble the class I polymorphs in size and shape. The granules in the cytoplasm are coarser and are concentrated about the nucleus.

f—The differential count is as follows:

P. M. N.	63	L.	23
P. M. E.	5	L. M.	4
P. M. B.	3	T.	2

g—The polynuclear count is similar to that of man, and is as follows: 17 : 28 : 39 : 14 : 2.

II. Pan calvus (Chimpanzee)

a—The red cell size alone is worthy of record. The cells in plasma measure 7.8 μ, while dry cells measure 7.4 μ.

b—Haemoglobin, 89 per cent.

c—Red cell count, 7,300,000.

d—White cell count, 10,400.

e—The leucocytes of this animal show no variations worthy of note, except that the lymphocytes have an extremely thin layer of light blue cytoplasm about a large irregular nucleus. Small dark granules can be seen scattered at random in the scanty cytoplasm. The measurements of the white cells are:

P. M. N.	8-10 μ.	L.	7 μ.
P. M. E.	9 μ.	L. M.	11 μ.
P. M. B.	5-10 μ.	T.	(none found)

f—The differential count is as follows:

P. M. N.	58	L.	16
P. M. E.	5	L. M.	1
P. M. B.	20	T.	—

g—The polynuclear count is 3 : 12 : 45 : 32 : 8.

h—The resistance of the red cells to haemolysins is as follows:

1—The resistance to saponin is 1.7 times that of the cells of man.

2—The resistance to taurocholate is 2.7 times that of human cells.

3—The red cells are resistant to 0.28 per cent NaCl, a resistance considerably greater than that of human erythrocytes.

III. Pongo pygmæus (Orang-utan)

a—The red cells in plasma measure 7.8 μ, while dried cells measure only 7.4 μ.

b—Haemoglobin, 80 per cent.

c—Red cell count, 6,880,000

d—White cell count 9,400.

e—The morphology of the leucocytes presents a few interesting features.

1—The polymorphs have an uneven outline which can be considered as roughly circular. They measure 10 μ in diameter. The nucleus is multilobed and uneven; the cytoplasm shows a variable staining reaction owing to the fact that it is studded with a mixture of eosinophile and basophile granules.

2—The eosinophiles are almost circular in outline, and measure 7 μ in diameter. The nucleus stains a light purple and is set in a poorly staining cytoplasm with coarse eosinophile granules.

3—The basophiles resemble small lymphocytes with coarse basophilic granules. The nucleus is fairly regular, but its outline is difficult to trace owing to the number of the cytoplasmic granules. The cytoplasm seen between the granules is light blue. The size varies from 5 to 8 μ.

4—The lymphocytes are about 5 μ in diameter. The time required for staining the smears of this blood is quite different from that ordinarily used. The initial staining proceeds rapidly (15 to 25 seconds), while the differentiation requires a full two minutes.

f—The differential count is:

P. M. N.	55	L.	24
P. M. E.	4	L. M.	2
P. M. B.	15	T.	—

g—The polynuclear count is 3 : 12 : 40 : 28 : 17.

IV. Papio cynocephalus (Yellow Baboon)

a—Red cells in plasma measure 7.7 μ, while dried cells measure 7.3 μ.

b—Haemoglobin, 87 per cent.

c—Red cell count, 6,970,000.

d—White cell count, 10,400.

e—With the exception of the size of the eosinophiles, which measure 17 μ, the white cells of this monkey show few differences from those of man. The transitional leucocytes are rather small, measuring only about 11 μ as opposed to the 20 μ measurement for the same cells in man. The sizes of the other white cells are given below:

P. M. N.	12 μ	L.	8 μ
P. M. B.	10 μ	L. M.	19 μ

f—The differential count is: —

P. M. N.	65	L	29
P. M. E.	2	L. M.	2
P. M. B.	1	T.	1

g—The polynuclear count is 10 : 25 : 40 : 20 : 5.

h—The resistance to saponin is 0.57 times that of human cells, and the resistance to taurocholate 0.42 times as great. The cells resist 0.18 per cent NaCl; this is a very great resistance indeed.

V. Lasiopyga griseoviridis (Green Monkey)

a—Cells in plasma measure 7.8 μ, while dried cells measure 7.4 μ.

b—Haemoglobin, 87 per cent.

c—Red cell count, 6,400,000.

d—White cell count, 12,600.

e—The staining properties and morphology of the cells require no description. The cells sizes are:—

P. M. N.	10 μ	L.	8 μ
P. M. E.	7 μ	L. M.	12 μ
P. M. B.	10 μ	T.	—

f—The differential count is:—

P. M. N.	58	L	31
P. M. E.	7	L. M.	3
P. M. B.	1	T.	none

g—The polynuclear count is 8 : 20 : 38 : 22 : 12.

h—The resistance to saponin is 0.9 times that of the cells of man; to taurocholate the resistance is 0.40. The cells are less resistant to NaCl than are the cells of man, haemolysing at 0.43 per cent.

VII. Magus maurus (Celebes Macaque)

a—Red cells in serum, 7.9 μ; in the dried state, 7.2 μ.

b—Haemoglobin, 88 per cent.

c—Red cell count, 5,000,000.

d—White cell count, 7,600.

e—The transitional leucocytes contain a mixture of basophilic and eosinophilic granules in addition to the typical lilac colored granules. Otherwise there is no noteworthy difference from the cells of man. The cell sizes are:—

P. M. N.	10 μ	L.	23 μ
P. M. E.	9 μ	L. M.	14 μ
P. M. B.	8 μ	T.	19 μ

f—The differential count is:—

P. M. N.	69	L.	23
P. M. E.	2	L. M.	1
P. M. B.	4	T.	1

g—The polynuclear count is 32 : 32 : 31 : 5 : 0.

h—The resistance to saponin is 1.55 times as great as in man, while the resistance to taurocholate is 0.55 times as great. The cells resist 0.22 per cent NaCl.

VI. Pithecus rhesus (Rhesus Monkey)

a—Red cells in plasma measure 8.0 μ, while dried cells measure 7.3 μ.

b -Haemoglobin 77 per cent.

c—Red cell count, 5,000,000.

d—White cell count, 10,400.

e—The blood elements of this form are decidedly chromophilic, for they stain easily and differentiate rapidly. The lymphocytes especially show a marked differential staining. Their cytoplasm stains a beautiful blue, while the azure granules stand out in bold relief. The cell sizes are:—

P. M. N.	5 μ	L.	5 μ
P. M. E.	6 μ	L. M.	12 μ
P. M. B.	7 μ	T.	—

These cells are all rather small in size, the largest being no bigger than a polymorph of human blood.

f—The differential count is:—

P. M. N.	73	L	18
P. M. E.	3	L. M.	2
P. M. B.	1	T.	none

g—The polynuclear count is 12 : 32 : 40 : 14 : 2.

h—The resistance to saponin is 0.73 times that of human cells, while to taurocholate it is approximately the same. The cells resist 0.27 per cent NaCl, and are therefore more resistant than the cells of man.

VIII. Pithecus irus (Common Macaque)

a—Red cells in serum, 8.0 μ: in dried films, 7.1 μ.

b—Haemoglobin, 90 per cent.

c—Red cell count, 6,432,000.

d—White cell count, 7,200.

e—The polymorphs are typical, and measure 10 μ in diameter. The eosinophiles occur in quite large numbers, and measure 8 μ in diameter; their granules are large and uniform, and stain an intense red. The nucleus is less lobated than usual. The basophiles are also numerous, and measure 7-12 μ. The lymphocytes measure 10 μ, the mononuclears 15 μ, and the transitionals 11 μ.

f—The differential count is:—

P. M. N.	37	L.	18
P. M. E.	19	L. M.	1
P. M. B.	24	T.	1

g—The polynuclear count is 18 : 37 : 39 : 6 : 0.

h—The resistance of the red cells is given by the following figures: saponin, 1.0, taurocholate, 0.49, hypotonic saline, 0.16 per cent NaCl. This latter is the greatest resistance yet recorded.

IX. Cebus fatuellus (Sapajou)

a—Red cells in plasma, 7.8 μ; in dried films, 6.8 μ.

b—Haemoglobin, 90 per cent.

c—Red cell count, 5,100,000.

d—White cell count, 10,400.

e—The polymorphs are difficult to stain properly, and the nucleus is obscured by the eosinophilic and basophilic granules which fill the cytoplasm. There are some neutrophile granules present. The size of these cells is 13 μ. The lymphocytes are peculiar in that they contain an irregular nucleus with slightly scalloped margins. The cell sizes are:—

P. M. N.	13 μ	L.	8 μ
P. M. E.	10 μ	L. M.	11 μ
P. M. B.	7 μ	T.	11 μ

f—The differential count is:—

P. M. N.	68	L.	21
P. M. E.	5	L. M.	2
P. M. B.	3	T.	1

g—The polynuclear count is 10 : 22 : 42 : 18 : 8.

h—The resistance to haemolysins is shown by the following figures: saponin, 1.42, taurocholate, 1.12, hypotonic saline, 0.38 per cent NaCl.

X. Ateleus ater (Black Spider Monkey)

a—Red cells in plasma, 9.1 μ; in dried films, 7.7 μ.

b—Haemoglobin, 76 per cent.

c—Red cell count, 5,760,000.

d—White cell count, 10,000.

e—The eosinophiles are peculiar in that areas of the cytoplasm do not contain granules of any kind. The large bright red granules are concentrated on one side of the nucleus, leaving the remaining part of the clear light blue

cytoplasm devoid of granules. No large mononuclears or transitional cells appear to be present. The sizes of the cells are:—

P. M. N.	13 17 μ	L.	10 μ
P. M. E.	12 μ	L. M.	—
P. M. B.	8 μ	T.	—

f—Differential count: –

P. M. N.	69	L.	18
P. M. E.	12	L. M.	none
P. M. B.	1	T.	none

g—Polynuclear count: –3 : 6 : 5 : 10 : 10 : 10 : 14 : 42. This is a most remarkable count, for not only are there eight classes, but as many as 42 cells show eight nuclear lobes.

h—Resistance to haemolysins: –saponin, 1.24, taurocholate, 1.63, hypotonic saline, 0.28 per cent NaCl.

XI. *Ateleus geoffroyi* (Gray Spider Monkey)

a–Red cells in plasma, 8.8 μ; in dried films, 7.9 μ.

b–Haemoglobin, 80 per cent.

c–Red cell count, 3,840,000.

d—White cell count, 7,000.

e—The polymorphs are approximately 10 μ in diameter, and contain extremely lightly staining cytoplasm filled with fine neutrophile granules. The basophiles appear to be composed almost entirely of nuclear material, only a few basophilic granules being resolvable at the edge of the cell. The lymphocytes also have very little cytoplasm, and contain a few azure granules. The large mononuclears have a clear sky blue cytoplasm which contains no granules at all. The cell sizes are: –

P. M. N.	10 μ	L.	8 μ
P. M. E.	11 μ	L. M.	13 μ
P. M. B.	6 8 μ	T.	—

f—Differential count:

P. M. N.	73	L.	15
P. M. E.	8	L. M.	1
P. M. B.	3	T.	none

g–Polynuclear count: 8 : 18 : 21 : 29 : 19 : 4 : 1. Like the count of Ateles ater, the count is very right handed.

h—Resistance to haemolysins: –saponin, 1.28, taurocholate, 1.46, hypotonic saline 0.28 per cent NaCl.

XII. *Saimiri sciureus* (Squirrel Monkey)

a—Red cells in serum, 6.4 μ; in dried films, 6.1 μ.

b–Haemoglobin, 84 per cent.

c–Red cell count, 7,416,000.

d—White cell count, 11,000.

e–The lymphocytes can properly be divided into small and large, for they show a wide variation in size (5-14 μ). The other cells are typical. The sizes are:—

P. M. N.	10 μ	L.	5-14 μ
P. M. E.	8 μ	L. M.	12 μ
P. M. B.	8 μ	T.	—

f—Differential count:—

P. M. N.	65	L.	26
P. M. E.	6	L. M.	1
P. M. B.	2	T.	none

g—Polynuclear count:—8 : 15 : 30 : 22: 15 : 10.

h—Resistance to haemolysins:—saponin, 0.90, taurocholate, 0.95, hypotonic saline, 0.27 per cent NaCl.

XIII. Aotus trivirgatus (Owl Monkey)

a—Red cells in serum, 7.1 μ; in dried films, 6.7 μ.

b—Haemoglobin, 71 per cent.

c—Red cell count, 4,664,000.

d—White cell count, 8,200.

e—The films are exceedingly difficult to stain, owing to the serum taking on a grayish-blue color which obscures the cell outline. Direct fixation with methyl alcohol before staining seems to help, but no satisfactory technique has been developed for dealing with the blood films of this animal. Except that there are no large mononuclears or transitional cells, all the leucocytes observed were found to be typical. The cells sizes are:—

P. M. N.	7 μ	P. M. B.	8 μ
P. M. E.	10 μ	L.	9-10 μ

f—Differential count:—

P. M. N.	79	P. M. B.	1
P. M. E.	8	L.	12

g—Polynuclear count:—6 : 20 : 34 : 16 : 4.

XIV. Callithrix jacchus (Marmoset)

a—Red cells in serum, 7.7 μ; in dried films, 7.0 μ.

b—Haemoglobin, 67 per cent.

c—Red cell count, 6,624,000.

d—White cell count, 7,800.

e—The mononuclears are atypical in that the cytoplasm stains a light blue and is filled with fine purple granules which are evenly distributed. The nucleus is approximately central. The cell sizes are:—

P. M. N.	10-11 μ	L.	5-9 μ
P. M. E.	11 μ	L. M.	16 μ
P. M. B.	8 μ	T.	—

f—Differential count:—

P. M. N.	72	L.	19
P. M. E.	2	L. M.	3
P. M. B.	4	T.	none

g—Polynuclear count:—35 : 32 : 28 : 5 : 0. This count is a little left handed.

h—Resistance to haemolysins:—saponin, 0.57, taurocholate, 0.71, hypotonic saline, 0.40 per cent NaCl.

XV. Lemur catta (Ring-tailed Lemur)

a—Red cells in plasma, 6.8 μ; in dried films, 6.3 μ.
b—Haemoglobin, 87 per cent.
c—Red cell count, 7,936,000.
d—White cell count, 16,400.
e—The polymorphs are typical except that they contain some rather coarse neutrophile granules. The eosinophiles contain peculiar red granules, characterized by their hyaline appearance. The lymphocytes contain an exceedingly small amount of cytoplasm. The sizes are:—

P. M. N.	10 μ	L.	6–8 μ
P. M. E.	10 μ	L. M.	12 μ
P. M. B.	9 μ	T.	13 μ

f—Differential count:—

P. M. N.	66	L.	23
P. M. E.	7	L. M.	1
P. M. B.	2	T.	1

g—Polynuclear count: - 5 : 25 : 38 : 25 : 7.
h—Resistance to haemolysins: –saponin, 0.64, taurocholate, 1.0, hypotonic saline 0.42. This latter figure is greater than that for the cells of man.

XVI. Lemur mongos (Brown Lemur)

a—Red cells in plasma, 6.7 μ; in dried films, 6.3 μ.
b—Haemoglobin, 75 per cent.
c—Red cell count, 10,304,000.
d—White cell count, 15,400.
e—No transitional or mononuclear cells could be found. The eosinophiles contain only a few red staining granules. The basophiles also contain few granules. The sizes are:—

P. M. N.	10 μ	P. M. B.	6–8 μ
P. M. E.	11 μ	L.	9–12 μ

f—Differential counts:- -

P. M. N.	69	L.	27
P. M. E.	1	L. M.	none
P. M. B.	3	T.	none

g—Polynuclear count: –5: 18 : 40 : 25 : 10 : 2.

Atypical leucocytes

While examining the stained smears of the blood of the sapajou, gorilla, and squirrel monkey, a large polymorphonuclear leucocyte was encountered, which measured from 18 23 μ in diameter. The nucleus is typically polymorphic, stains a deep purple, and has at least four lobes. The cytoplasm is clear, stains light pink, and contains no granules. It occurs approximately once in every 200 cells.

Summary

Except for small differences of size the red cells of the Primates resemble those of man. The largest cells are those of the spider monkeys while the smallest are those of the lemurs. The red cell counts vary from 5,000,000 to 7,000,000 and the haemoglobin content from 75 to 90 per cent. The erythrocytes offer considerable variations in their resistance to haemolysis by simple haemolysins, but are in general considerably more resistant to hypotonic saline haemolysis than are human cells. The morphology of the white cells is very similar to that found in man, minor differences only being found, and the differential counts present no unusual features. The total white cell count varies from 7,000 to 16,000. For most genera of monkeys the polynuclear count is more right-handed than the count for man and in the case of Ateles ater as many as 40 per cent of the polymorphs may be cells containing 7 nuclear lobes.

A fuller account of the haematology of the Primates will be found in the Quarterly Journal of Experimental Physiology, vol. xix.

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DIRECT BONE FORMATION IN THE ANTLER TINES OF TWO OF THE AMERICAN CERVIDAE, VIRGINIA DEER (*Odocoileus virginianus*) AND WAPITI (*Cervus canadensis*)

WITH AN INTRODUCTION ON THE GROSS STRUCTURE OF ANTLERS

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Illustrations from photographs made in the Zoological Park

INTRODUCTION

(Figs. 1 to 56 incl.)

This paper is the report of a study of the gross and microscopic structure of growing antler tines in Virginia deer (*Odocoileus virginianus*) and the wapiti or American elk (*Cervus canadensis*). The major portion of the histological work was confined to a study of the tip of a growing wapiti antler. A similar histological study of the tip of a growing antler in the Virginia deer indicated that essentially the same process of growth is present in the growing antler tines of both of these American Cervidae. It is not our purpose to consider the general external structure such as the size and pattern of antlers, as this subject has been treated in works on natural history [Hornaday (18)].

A striking and impressive feature of antler-bearing Cervidae is that these large osseous structures are shed and renewed annually. One is impressed by the size and strength of these very rapidly growing osseous structures, which present perhaps the most rapid growth of membranous bone found in mammals.

Numerous descriptions are given of the number of tines or branches that antlers possess, and such terms as brow, bez, trez, royal, sur-royal and crown tines are frequently used in general descriptions of antlers. Aristotle (1) (384 to 322 B. C.) considered them as secondary sexual characters and noted that they were shed annually. "If stags are castrated before they are old enough to have horns [antlers], these never appear; but if castrated after they have horns [antlers], their size never varies, nor are they subject to their annual change." Redi in 1657 quoted by Owen (2) expresses the same

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opinion as Aristotle but gives no experimental data to support his views. In 1766 Buffon et Daubeton (3) in their "Histoire naturelle général" make the same statement regarding antlers and castration.

Prior to the nineteenth century, writers seem to have confined their records to descriptions of the general antler pattern, shedding, and the effects of castration. Since this paper will not deal with castration effects we will proceed to note some of the views that have been held on the structure and composition of antlers.

As late as 1758 Buffon (4) expressed the opinion that antlers were composed of wood, growing in a manner similar to the growth of the branches of a tree. Barr's (5) translation of Buffon's Works in 1807 contains the following reference on a red deer antler. "Its substance is perhaps more of the nature of wood than bone; it is, as it were, a vegetable grafted upon the animal." The velvet was designated as écorcé (bark). "Bois" is frequently used by the French to designate an antler.

The earliest references on the actual composition of antlers which we were able to find were those of Chevrueil (6) (1818) and Georges Cuvier (7) (1817). These writers were apparently the first to recognize and record the fact that the cervine antler is composed of bone. The former states that the antler of ruminants consists of bone and that on boiling, the organic matter is converted into gelatine, and that no fat is present. Cuvier (7) in an article under Cerf states, "antlers are composed of bone."

Johannes Müller (8) (1825) believed that the bony core of the ruminant horn and the antler are similar in structure, and considers the tubercle of the budding antler to consist of cartilage which ossifies in a manner similar to bones of the foetal skeleton. Gegenbaur (9) (1867) describes the ossification of the antler as an exceptional kind of cartilage metaplasia and agrees with Lieberkühn (10) (1864), who also believed that the antler was preformed in cartilage.

Landois (11) (1865) observed and recorded that the antler was not preformed in cartilage but in reality was a form of membranous bone. It remained for Robin et Herrmann (12) (1882) to confirm this finding and to present clear histological evidence as to the actual character and composition of the osseous structure of antlers. They gave a detailed description of the process of ossification and growth of the Roebuck (*Cervus capreolus*) antler from an undifferentiated connective tissue through a preosseous stage to membranous bone,

together with a description of the phases of osteoblastic development. They use the term preosseous substance (substance preosseous, or substance fondamental de l'os de Müller) to describe the clear amorphous material containing osteogenic fibrillae which surrounds the osteoblasts.

Gadow (13) (1902) in a paper on "The Evolution of Horns and Antlers" emphatically denies direct bone formation in the antler and describes the presence (page 210) of "a dense layer of hyaline cartilage which together with the rapidly proliferating connective tissue. . . . forms the growing point of the future pricket." He presents no original work in support of this statement. In reply to Dürst (14) (1902), who states that the bone of the antler is not formed by the intervention of cartilage, Gadow (13) states (page 222), "He [Dürst] and others will have to accustom themselves to the existence of cartilage in places where textbooks carefully abstain from mentioning it."

Fambach (15) (1909) in a critical review and by original work confirms the observations of Landois, Robin et Herrmann and Dürst on the structure of antlers.

Macewen (16) (1920) page xi, states, "The inquiry into the phenomena connected with the growth and shedding of the deciduous antler of the deer is undertaken to determine the data of a very interesting phase of nature which had not already been investigated, was imperfectly understood and which on its own merits, was of intrinsic value." Without referring to any previous work on the histogenesis of the bone in the antler he concludes from original work that (page 49). "The antlers showed a vigorous formation of bone through cartilage of the main stem and the basal portions of the tines, while the terminal parts of the same tines developed through direct bone formation."

Before going into a detailed account on the structure of antlers we feel it advisable to review the gross characteristics which differentiate the antler from the hollow horn of ruminants. The cervine antler is a deciduous bony protuberance arising from the pedicle of the frontal bone, covered with a true skin, the velvet, during its period of growth. This velvet is shed after ossification has been completed. Horns may be considered as the permanent keratogenous sheaths of ectodermal origin which enclose an osseous core arising from the frontal bone of the hollow-horned ruminants. Horns are present in both sexes, and except in the prong-horned antelope,

are never shed. The prong-horned antelope sheds its horns each year.

The males of all Cervidae with the exception of the Chinese water deer (*Hydropotes inermis*) are antler-bearing, while in the caribou (*Rangifer caribou*) and reindeer (*Rangifer tarandus*) both sexes bear deciduous antlers.

As the antlers of American deer are in process of growth from April to October, it will be realized that it is very difficult to obtain material for study without injury to the animal. The specimens used in this investigation were obtained from accidentally broken antlers.

Gross External Antler Structure

At birth the antler-bearing young present no external indication of an ensuing antler. Several months after birth small paired bulges of the frontal bone, covered with the skin of the head, begin to appear anteriorly and laterally on the frontal bone. These bulges grow with marked rapidity to form the pedicle. The first antler grows from the tip of this pedicle when the deer is about eighteen months old. Ossification of the antler begins at the base and keeps pace with the growing tip, so that a section at any level is harder than that above it and less ossified than that below. Growth continues until the pattern of the species and individual is completed, ossification continuing until the tip has become ossified, after which the velvet is shed. The antler does not increase in diameter as it grows in length [Caton (17)] except at the corona around the base, which is the only region showing an increase in diameter. The external appearance of the annually recurring cycle of successive changes of the wapiti antler is illustrated in the accompanying series of photographs by Sanborn (20) (Figs. 1-16) and also described by Hornaday (18).

The Velvet

The velvet which envelops the growing antler is an extension from the skin of the head (Fig. 23). After the antler has been shed it regenerates and grows from the adjacent cutaneous border to cover the tip of the pedicle. It is noteworthy that the velvet does not in any way resemble scar tissue but contains all the elements of cervine skin.

The velvet may be separated into three layers—an innermost

fibrous layer, the corium, and a peripheral epidermal layer (Figs. 17, 18 and 19). The fibrous layer, consisting of coarse collagen fibers arranged longitudinally, is quite vascular and gradually merges with the deeper undifferentiated connective tissue layer (Fig. 20). A few capillaries may be seen to pass from the fibrous layer of the velvet and to enter the layer of undifferentiated connective tissue in the region of the growing tip.

The corium (Figs. 17, 18 and 19) lies peripheral to the fibrous layer, containing hair follicles and sebaceous glands together with many fibrillae arranged in various directions, but most of the fibrillae are at right angles to the epidermal layer (Fig. 18). The hair follicles with the ducts of their sebaceous glands pierce the epidermis (Figs. 17 and 19). Paccinian corpuscles, Meissner's corpuscles, nerves and free nerve endings have not been demonstrated with hematoxylin and Orange G or Del Rio Hortega's silver carbonate method. The epidermal layer forms the outer coat of the velvet (Figs. 17, 18 and 19) and corresponds to the ectoderm (keratogenous layer) of skin.

Gross Internal Antler Structure

Figures 22 to 28 illustrate the gross internal structure of Virginia deer antlers in successive stages of seasonal growth. Fig. 29 illustrates the gross external appearance and Fig. 30 the gross internal appearance of the tip of the growing wapiti antler. (Old antler shed April 18, 1929; specimen obtained through accident July 2, 1929.)

The following description of the gross internal structure of the deer antler is primarily based upon a study [Noback (19)] of three antlers from the Virginia deer (*Odocoileus virginianus*) and the head of a Columbia black-tailed deer (*Virginianus columbianus*). These specimens were obtained at the New York Zoological Park during the summer of 1928. The first, an antler in early velvet, representing about two months' growth, was obtained on June 1, 1928. The second antler, representing a growth of about four months, came from a buck which died on July 25, 1928. The third, representing about six months' growth, was secured on October 4, 1928. The head of the Columbia black-tailed deer came from an old buck which died on January 28, 1929, four weeks after shedding its antlers.

In the latitude of New York, during late winter or early spring of each year, the mature antler is shed, after which a new one grows from the tip of the pedicle. The exposed surface of the osseous pedi-

cle (Figs. 22 and 23) is bare at the time of shedding. The marginal border of skin is the source of a cutaneous structure, the velvet, which soon envelops the free surface. While the velvet is developing, a mass of undifferentiated connective tissue, embryonic in character, is beginning to form. The growth of modified skin, the velvet, which later becomes covered with fine short hair, protects the connective tissue cap.

It may be noted that the pedicle is a cylindrical outgrowth from and a part of the frontal bone of the skull. The relation of the frontal bone to the pedicle is shown in Fig. 28. The blood supply of the pedicle is derived from the internal vascular system of the frontal bone.

A gross examination of the tine of a growing antler reveals that it is elastic in consistency while its cut surface presents a glistening bluish-white appearance which grossly resembles cartilage. Microscopic examination, however, reveals that the tip of the growing antler consists of a mass of newly formed undifferentiated connective tissue.

Growth of the antler seems to take place somewhat as follows: The cap of undifferentiated connective tissue "grows out" while the tissue at the base ossifies. Bone formation is more intense within the wall of the antler so that on examination we find that the wall of the cylindrical antler shaft is very compact in comparison with the interior. The interior of the antler is filled with a mass of soft bone tissue, a veritable network of fine blood channels which serve to supply the growing tip with an adequate amount of blood from the Haversian systems of the pedicle and frontal bone. The growing tip is primarily dependent for its nourishment upon blood received from the frontal bone through the pedicle and partly from the blood vessels of the velvet.

The gross internal structure of the tines of a young growing antler is illustrated in the accompanying photograph (Fig. 24) of a longitudinal section through a two months' growth of antler in velvet. The photographed specimen was secured on June 1, 1928 as the result of an accident. All the stages of growth in a growing antler tine may be seen in this photograph. A good view of the velvet and its hair may be seen in Fig. 25, a cross section from the beam of the antler where blood vessels in the velvet are plainly visible. The gross structure of the growing shaft is seen to consist of spongy bone richly

supplied with blood, while the wall consists of compact bone where calcification is more complete. The growing bone imperceptibly merges with the undifferentiated connective tissue.

A later stage illustrating the internal structure of a four months old antler is shown in Fig. 26. It will be seen that the clear tip has been practically replaced by new bone. It may be seen that the velvet covering the tip of the antler has begun to degenerate, as indicated by its darkening and drying out.

Figure 28 shows the internal structure of the mature antler, pedicle and frontal bone obtained by a longitudinal section. This antler is bare, free of velvet, and is composed solely of bone. The wall of the mature antler is seen to consist of hard compact bone while the interior still contains spongy, vascularized bone. The base of the antler is firm and compact, with a ring of bone overflowing the base to form the corona or burr. The line of demarcation between antler and pedicle is clear and distinct. It is along this line that separation from the pedicle takes place when the antler is shed and it is from this area on the pedicle that a new antler will grow. Complete ossification of a mature antler tip can be seen in Fig. 27.

Sections for microscopic study were obtained from the growing tip of a 75-day old wapiti antler. A close view of the exterior of the wapiti antler tine is illustrated in Fig. 29, showing the hair of the velvet very distinctly. The external appearance of an antler of essentially the same age can be seen on the wapiti in Fig. 12. A longitudinal section showing the gross internal structure of this antler tine can be seen in Fig. 30.

From within, the following three layers in the antler tine may be identified—a core of preosseous tissue in the process of ossification (Fig. 30), a layer of undifferentiated connective tissue, and the velvet. The layer of undifferentiated connective tissue is very thick at the tip where it forms a cap. It continues down the sides of the antler, gradually becoming narrower until it finally becomes imperceptible.

Microscopic Structure of Growing Antler Tine

The growing tines of a 75-day old wapiti antler and a two months' old antler from a Virginia deer were used to study the process of ossification in the tip of a growing antler. Del Rio Hortega's silver carbonate method was used as a general staining procedure to

demonstrate cellular as well as fibrillar structure. A modification of this method was used to demonstrate the fibrillar network.

DEL RIO HORTEGA SILVER CARBONATE METHOD

1. Fix the tissue in a ten per cent. (10%) neutral formalin solution (excess of magnesium carbonate in formalin).
2. Cut sections, with a freezing microtome, 15 to 20 microns thick.
3. Wash the sections thoroughly in distilled water. A few drops of ammonium hydroxide should be added to the first wash water.
4. Sections are stained in the silver carbonate solution, which solution is prepared as follows:

Five (5) c. c. of a ten per cent. (10%) aqueous solution of silver nitrate (Ag NO3) [Merck] are added to twenty (20) c. c. of a five per cent. (5%) solution of sodium carbonate (Na2 CO3) [Merck]. Without separating the precipitate add ammonia drop by drop until the precipitate is dissolved. Shake the beaker while adding the ammonia and be careful not to add too much. Finally add fifty (50) c.c. of distilled water and keep the solution in a dark brown bottle where it should keep well for several weeks.

The method of staining follows:

Wash the sections in a small Stender, then place them in ten (10) to fifteen (15) c. c. of the silver carbonate solution. Heat gently until a temperature of fifty (50) degrees Centigrade is attained or until the sections become yellowish brown. Discard the silver solution.

5. Before the silver solution cools, transfer the sections to distilled water and wash for from one-half (½) to one (1) minute.
6. Reduce the silver in a solution of fifteen (15) per cent. neutral formalin.
7. Wash thoroughly in distilled water. Examine under the microscope. If too pale place in silver carbonate solution again and repeat the whole procedure.
8. Tone with a two-tenths (0.2) per cent. aqueous gold chloride solution until grayish purple (five to ten minutes).
9. Wash in distilled water.
10. Fix with a five per cent. (5%) aqueous solution of sodium hyposulphite (sodium thiosulphite) for one to two minutes.
11. Wash very thoroughly in distilled water.
12. Run through alcohols 80%, 90% and absolute.
13. Clear in following solution:

Carbolic Acid crystals	5 grams
Creosote	50 c.c.
Xylol	45 c.c.

14. Mount in Dammar or Balsam.

The Modification which brings out the fibrillar structure consists of:

1. Fixation in neutral formalin (excess of magnesium carbonate in formalin) for at least a week.
2. Place in following solution for three days:

94 c.c. of a ten per cent. (10%) neutral formalin solution.
6 c.c. of concentrated Nitric acid.

3. Add two drops of concentrated ammonia to wash water.
4. The procedure given above is then followed.

Microscopic examination reveals an imperceptible merging of the fibrous layer of the velvet with the contiguous layer of undifferentiated connective tissue (Fig. 20). A definite line of demarcation between the undifferentiated connective tissue and the region of active ossification is present only where ossification is pronounced (Figs. 17, 31 and 32). A periosteum, as found in long bones, consisting of an outer fibrous restraining membrane with an inner osteogenic layer, is not present in the growing antler.

The undifferentiated connective tissue is composed of many layers of fusiform cells. These cells, with large dark, ovoid nuclei (Figs. 33 and 34), resemble those found in mysenchyma. For the most part, they are arranged parallel to the curvature of the cap. A delicate fibrillar network can be seen throughout this layer (Fig. 51), apparently continuous with the somewhat heavier fibers of the velvet. In lower sections along the sides of the ossifying core where ossification is distinct (Fig. 17), it is possible to measure the thickness of the undifferentiated connective tissue layer. In a cross section 3.0 cm. from the tip of the antler the undifferentiated connective tissue layer is 1.1 mm. thick; at 4.0 cm. it is 1.0 mm.; at 5.0 cm. it is 0.9 mm.; at 5.5 it is 0.75 mm. in thickness. These measurements indicate the gradual narrowing of this layer.

The presence of fusiform cells, with large, dark, ovoid nuclei, in the cap has been noted above (Figs. 33 and 34). Following a longitudinal section proximally, the aspect of these cells greatly changes (Fig. 43). They become larger, rounder and more granular, gradually losing their processes. Their nuclei which also become larger and rounder eventually assume an eccentric position in the cell. Longitudinal series of thin elongated cells with long darkly staining nuclei and lightly staining cytoplasm occasionally break through the layers of undifferentiated connective tissue cells just below the tip of the cap (Figs. 34 to 42). This series of cells seems to represent the evolution of the undifferentiated cell into an endothelial cell. The remaining cells are grouped around the evolving endothelial cells, so that in cross section 0.5 cm. to 1.5 cm. from the tip of the antler the appearance is presented of small masses of thin cells with lightly staining cytoplasm surrounded by the larger slightly basophilic cells. These actively proliferating basophilic cells derived from the undiffer-

entiated connective tissue of the cap possess fibroblastic characteristics.

In the lower sections these fibroblastic cells, enmeshed in a network of compacted fibrils, are more mature (Figs. 52, 53 and 54). Still lower (below 3.0 cm.) they show a clearing of cytoplasmic granules and signs of beginning atrophy (Figs. 43 and 55).

No spaces have been observed, in the masses of cells destined to form the endothelial lining of the blood channels, within two centimetres of the tip of the antler (Fig. 40). Below this level the developing endothelial cells gradualy form the lining of the blood channels (Figs. 35, 36 and 42) which are continuous with the wider channels below, bringing blood from the vessels of the diplöe of the frontal bone.

Two centimetres below the tip, cells from the periphery proliferate toward the newly forming centres of ossification (Figs. 44 to 50). The type of cell from which they originate is apparently of the same morphological character as those found in the cap. Their evolution seems to be more rapid, i. e., the series of cells representing the phases of the osteoblastic development is shorter than the series in the development of the fibroblastic cells originating from the cap.

Differing slightly in shape, the cell derived from the periphery has the definitive form of the osteoblasts (Figs. 46, 50 and 56). It is smaller, more basophilic, and more polygonal than the cell from the cap. The fibroblastic cells from the cap seem to lay down the fibrillar framework which later becomes ossified, while osteoblasts from the periphery apparently pass to the newly formed centres of ossification. Mitotic figures are present in the cells of the undifferentiated connective tissue and rare in the region of the matured osteoblasts.

As mentioned above, the tip of the cap shows a delicate fibrillar network (Fig. 51). As the developing fibroblasts increase in size they separate, while the fibrillar network spreads out to enclose them within its meshes, the fibrils coalesce to form a coarser network (Figs. 52, 53 and 54). Centres destined to become blood channels are devoid of the fibrillar network but contain a few delicate longitudinal fibrils (Figs. 51 and 52).

As the fibrillar network becomes coarser, the enmeshed cells at first show slight and later marked atrophy, together with a gradual disappearance of cytoplasmic granules (Figs. 43 and 55). Slight but definite centres of ossification first appear two centimetres below the

tip of the antler, immediately deep to the peripheral undifferentiated connective tissue. In this region of ossification the fibrils, becoming heavier, coalesce, the enclosed cells apparently atrophying from pressure. An occasional enclosed osteoblast does not atrophy and becomes an osteocyte of the mature antler bone. The trabecular framework is apparently formed by coalescence of fibrils (Fig. 54), beginning just under the peripheral undifferentiated connective tissue gradually extending distally and centrally.

Osteoblasts seem to migrate from the periphery to the spaces between the endothelium of the blood channels and the surrounding preosseous ring (Figs. 50 and 56). The migration of the osteoblasts from the periphery to the centre is made possible by a continuity of these spaces. The osteoblastic migration through these spaces seems to be the mechanism by which central ossification takes place. The process of ossification continues peripherally so that the wall of the antler finally consists of compact bone while the central portion remains spongy.

The vascular system of the growing antler consists of simple blood channels which are not surrounded by concentric lamellae which characterize the Haversian systems of skeletal bone. This sharply differentiates the bone of the antler from that of the pedicle.

The content of the blood channels in the antler apparently consists solely of blood. We have not been able to demonstrate the presence of fat or hematopoeitic elements found in the marrow of the diplöe of the membranous bones of the cranial vault.

Fibroblasts from the undifferentiated connective tissue cap lay down the ossifiable fibrillar framework while the osteoblasts from the periphery seem to complete the process of ossification.

The presence of fibrils in the matrix surrounding the fibroblasts and absence of cartilage during the entire process of growth leads us to conclude that the antler is a form of membranous bone.

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Fig. 1. *Upper.* The matured antlers of the wapiti are usually shed in March, occasionally in February. The exposed surface of the pedicle is shown after one antler had been dropped. Fig. 2. *Lower.* The appearance of the exposed pedicle tips after both antlers had been shed. Figs. 2, 9, 15 and 16 are used here for demonstration. The other figures are from the same animal.

Fig. 3. *Upper.* Antlers budding from the pedicle. April 26.
Fig. 4. *Lower.* The new antlers are beginning to show the branch-like form.

Fig 5 *Upper* The rapidity of growth is shown by the appearance of the antlers about the 5th of May Fig 6 *Lower* The branching of the antlers indicates their future pattern May 9

Fig. 7. *Upper.* The growing antler structure shows increased division on May 16, and the rough coat of old hair is shedding out. Fig. 8. *Lower.* As the antlers approach their normal size they become a prominent and striking feature of the male wapiti.

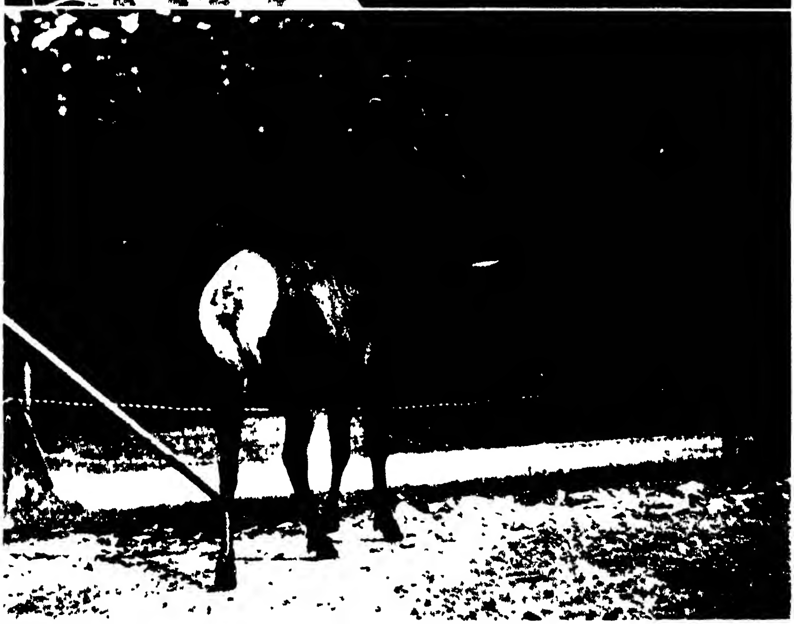

Fig. 9. *Upper.* During the period of development, while the antlers are in the velvet stage, the wapiti exercises the greatest care in avoiding hard objects. Fig. 10. *Lower.* The velvet masks the trim osseous structure of the antler.

Fig. 11 *Upper.* On July 6, the antlers are approaching the final stages of development. There is a noticeable shrinking of the velvet especially at the tips. Fig 12. *Lower.* In midsummer, July 12, the antlers have attained their greatest length.

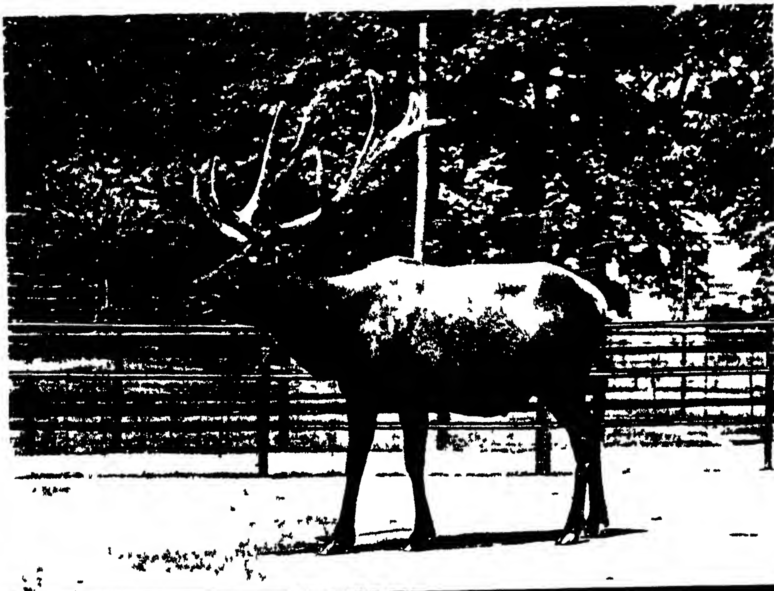

Fig. 13. *Upper.* The antler pattern is usually completed in August and at this time growth has ceased and the final stages of hardening are taking place.

Fig. 14. *Lower.* When the antler has become completely hardened the velvet dries out and peels from the bony structure in long thin ribbon-like strands.

Fig. 15. *Upper.* During the early stages of antler development the animal is most docile. Fig. 16. *Lower.* When the velvet is shed and his old vigor returns he then becomes very pugnacious and charges violently against any barrier.

Fig. 17. Cross section of Wapiti antler 10 cm below tip. 1, Velvet: a, Epidermal layer; b, Corium with sebaceous glands; c, Coarse fibrous layer. 2, Undifferentiated connective tissue layer. The open space in center is a capillary. 3, Ossifying zone. Obj. 48 mm. Ocular 8 comp.

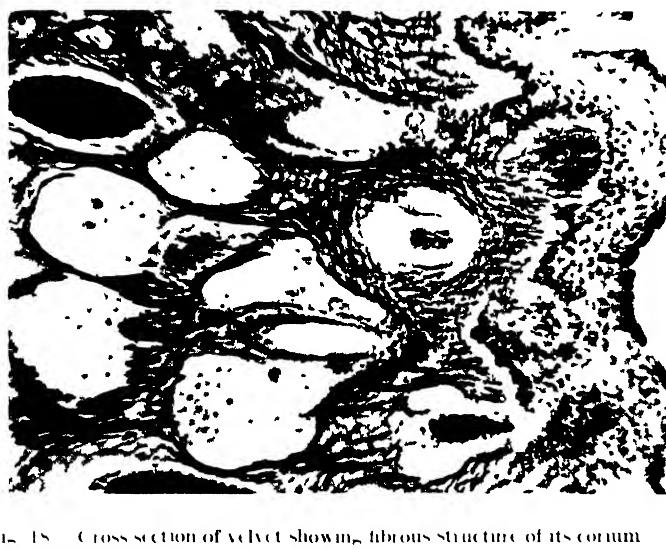

Fig. 18. Cross section of velvet showing fibrous structure of its corium. Obj. 32 mm. Ocular 8 comp.

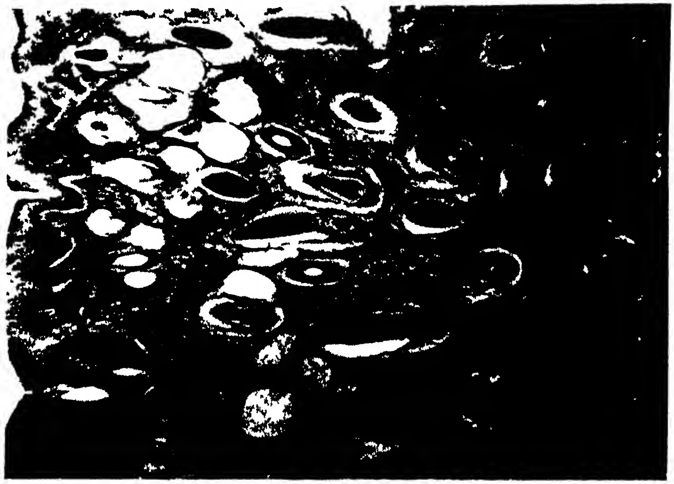

Fig. 19 Cross section of velvet Obj 32 mm. Ocular 8 × comp.

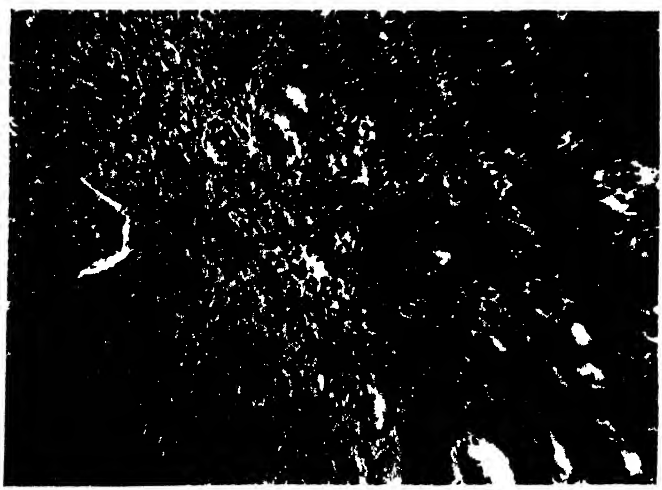

Fig 20 Cross section of antler showing the merging of the undifferentiated connective tissue with the fibrous layer of the velvet on the right. Obj. 16 mm Ocular 8 × comp.

Fig. 21. Cross section of antler showing fibrous layer and corium of the velvet. Obj. 16 mm., Ocular 8 comp.

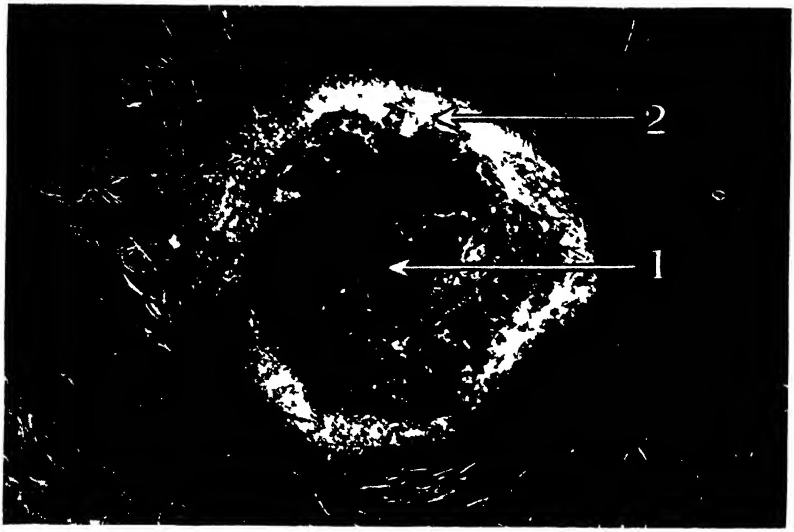

Fig. 22. Tip of pedicle of a Virginia deer two weeks after the antler had been shed. 1. A thin layer of dried blood scab covering the antler tip. Undifferentiated connective tissue, embryonic in character, is forming beneath the scab. 2. Edge of the pedicle skin surrounding the pedicle tip. The velvet, a form of skin, will evolve from this border to protect the delicate tip of the new antler.

Fig. 23. A longitudinal section through the pedicle of fig. 22 (Virginia deer). 1. Frontal bone, from which the new antler will derive most of its blood supply. 2. The pedicle, a cylindrical growth of bone from and a part of the frontal bone. 3. A layer of dried blood covering the tip of the pedicle two weeks after antler had been shed.

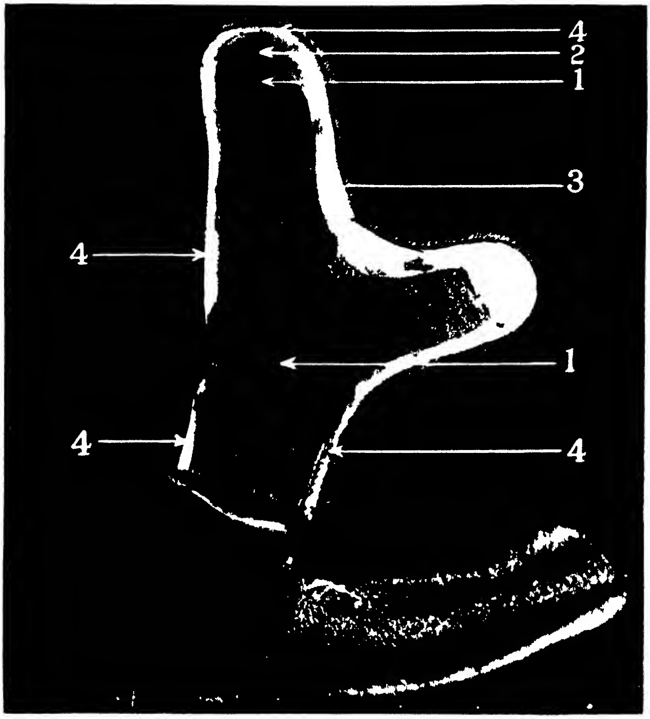

Fig. 24. Longitudinal section of a two months old Virginia deer antler showing its gross internal structure. 1. The ossifying core of undifferentiated connective tissue richly supplied with blood and containing areas in process of direct ossification together with spicules of newly formed bone. 2. Rapidly proliferating undifferentiated connective tissue embryonic character forming the growing tip of the antler. 3. Proliferating undifferentiated connective tissue continuing down the side of the antler tip. 4. The comparatively thick white border enveloping the antler is the velvet. The thin dark border of the velvet is the pigmented layer just beneath the hair.

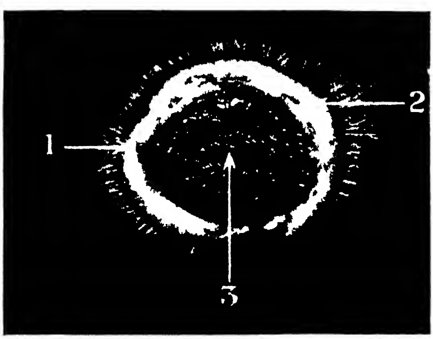

Fig. 25. Cross section of the two months old antler of Fig. 24. 1. The velvet, a thick cutaneous structure. 2. A blood vessel within the velvet. 3. The ossifying core of undifferentiated connective tissue.

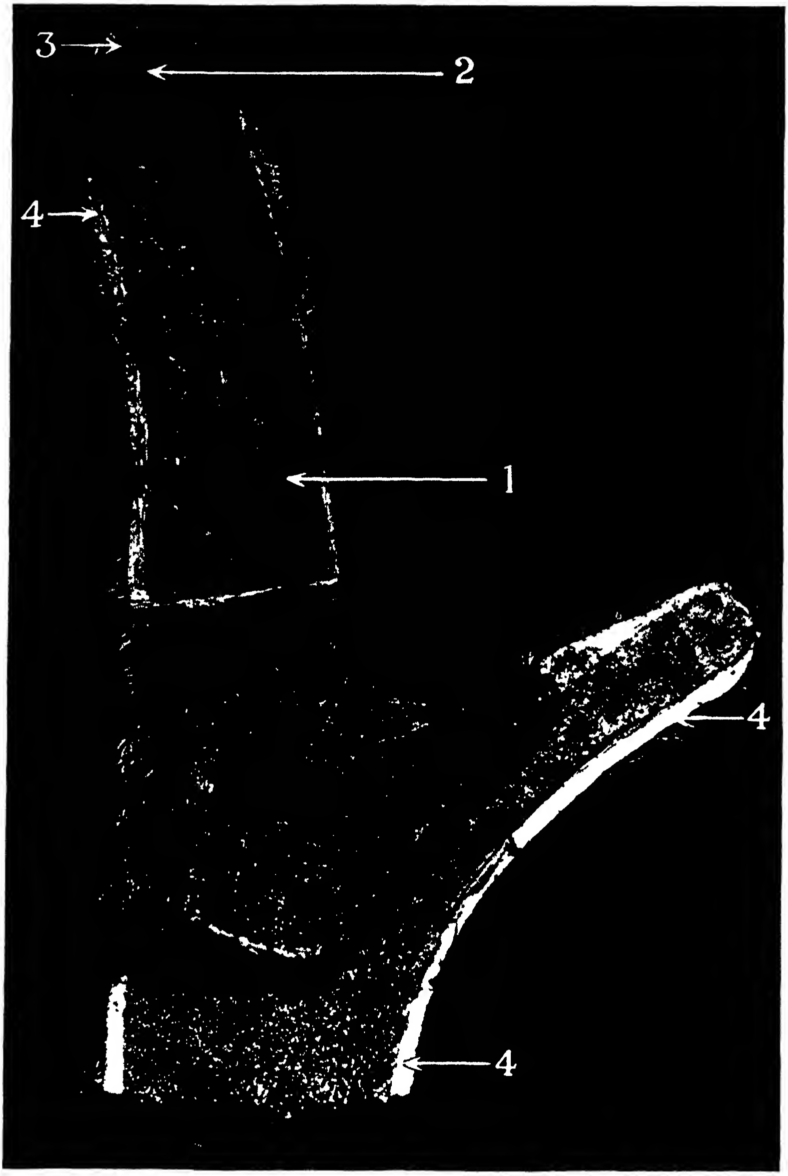

Fig 26. Longitudinal section of a four months' old antler. The undifferentiated connective tissue tip has been replaced by new directly formed bone; 1. Body or core of new directly formed compact bone; 2. Complete hardening and ossification of undifferentiated connective tissue tip; 3. Velvet of tip is dark, shriveled and dead. This is a point at which shedding of velvet begins; 4. Living velvet below the tip.

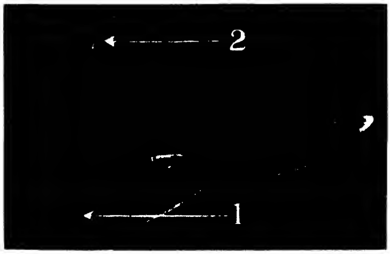

Fig 27 Completely ossified tip of mature antler; 1. Spongy area of interior; 2. Completely ossified tip.

Fig 28. Longitudinal section of mature antler and pedicle (Six months' old); 1 Frontal bone; 2. Pedicle, 3 Burr or corona; 4 Compact bone wall and base of mature antler, no velvet is present. 5. Spongy porous character of interior of antler.

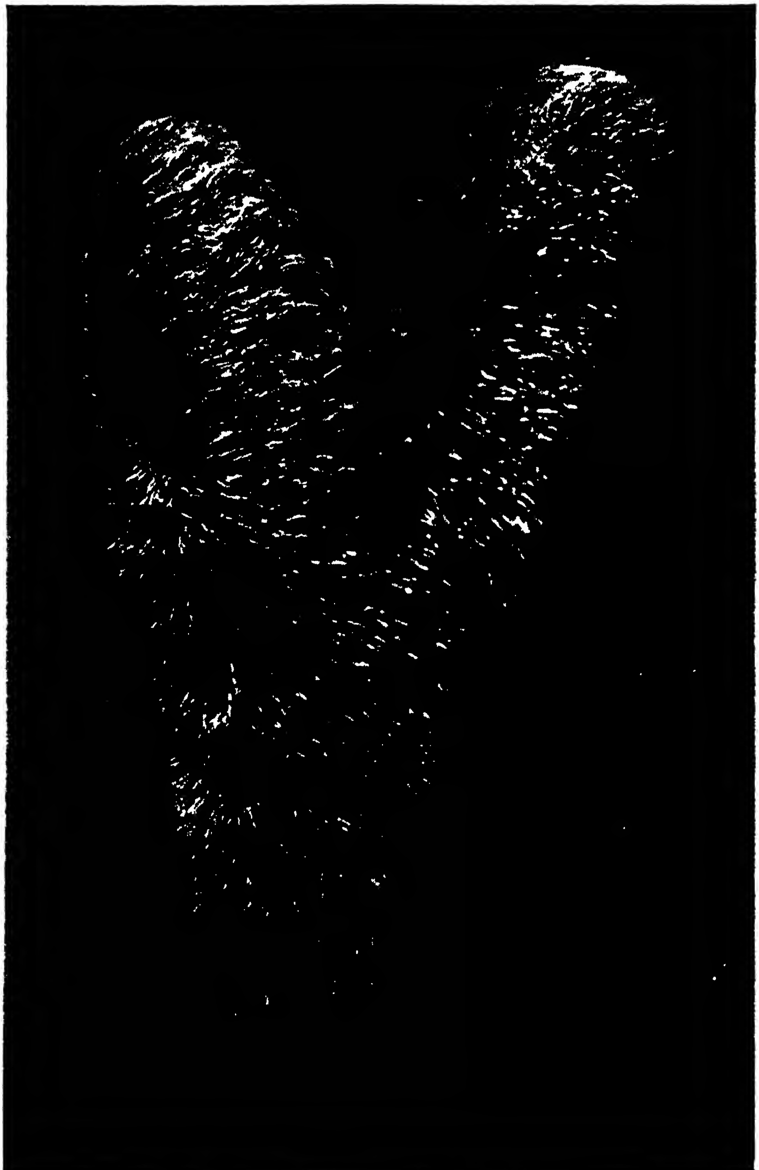

Fig. 29 External view of the tip of an elk antler 75 days old Note the hair of the velvet

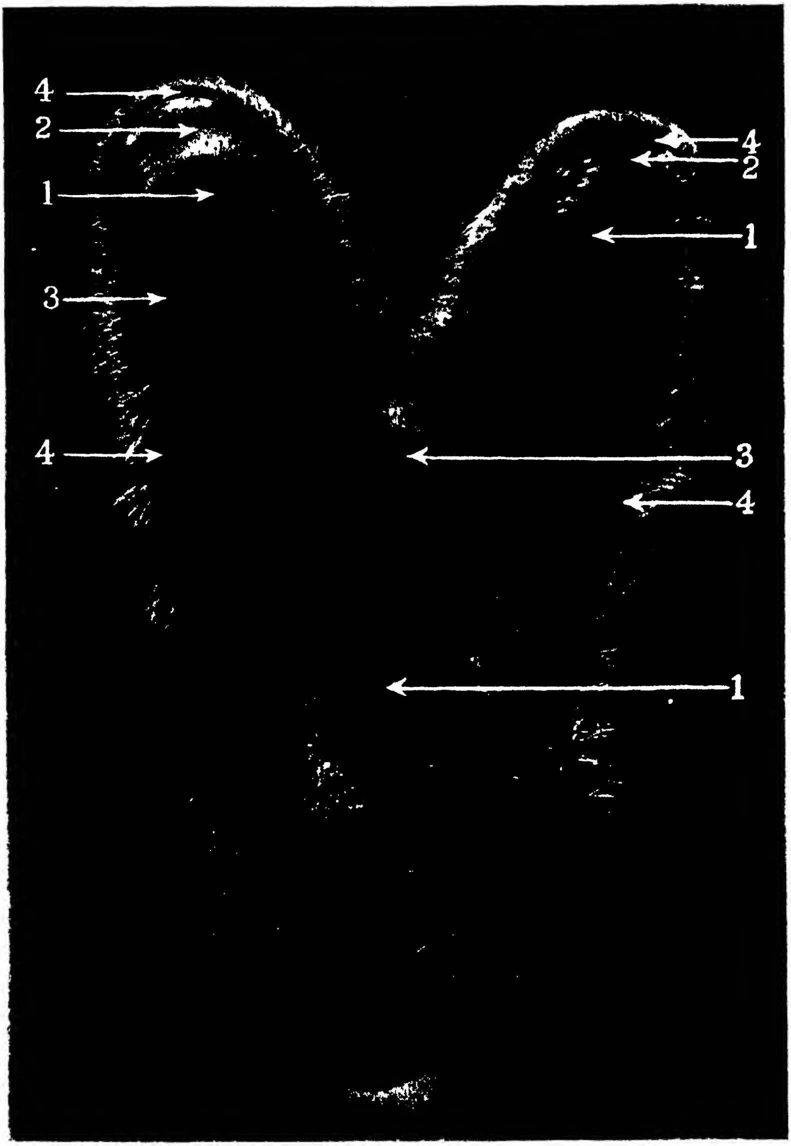

Fig. 30. Internal view of the antler of figure 29 on longitudinal section. 1. The ossifying core of undifferentiated connective tissue, richly supplied with blood and containing areas in process of direct ossification together with small areas of new formed bone. 2. Rapidly proliferating undifferentiated connective tissue, embryonic in character, forming the growing tip of the antler. 3. Proliferating undifferentiated connective tissue continuing down the side of the antler tip. 4. The layer of velvet enveloping the antler.

Fig. 31. Cross section 3.5 cm. from tip: ossification beginning peripherally. Obj. 16 mm. apochro. Ocular 8× comp.

Fig. 32. Cross section 4.5 cm. from tip showing pronounced peripheral ossification. Obj. 16 mm. apochro. Ocular 8× comp.

Fig. 33. Section through undifferentiated connective tissue showing typical spindle-shaped fibroblastic cells. Obj. 4 mm. Ocular 8× comp.

Fig. 34. Typical fibroblastic cells of the cap under oil immersion. Obj. 2 mm. oil imm.) Ocular 8× comp.

Fig. 35. Longitudinal section 1.5 cm. from tip showing evolving fibroblasts, endothelial cells and beginning blood channels. Obj. 32 mm. Ocular 8× comp.

Fig. 36. Longitudinal section 1.5 cm. from tip showing evolving fibroblasts, endothelial cells and beginning blood channels. Obj. 16 mm. Ocular 8× comp.

Fig. 37. Longitudinal section 2.0 cm. from tip showing evolving fibroblasts and open blood channels. Obj. 32 mm. Ocular 8× comp.

Fig. 38. Longitudinal section 2.5 cm. from tip showing maturing fibroblasts, open blood channels and slight centres of ossification. Obj. 32 mm. Ocular 8× comp.

Fig. 39. Typical fibroblastic cells 1.5 cm. from tip. Obj. 4 mm. Ocular comp.

Fig. 40. Cells 2.5 cm. from tip showing maturing fibroblasts and endothelial cells. Obj. 16 mm. Ocular 8× comp.

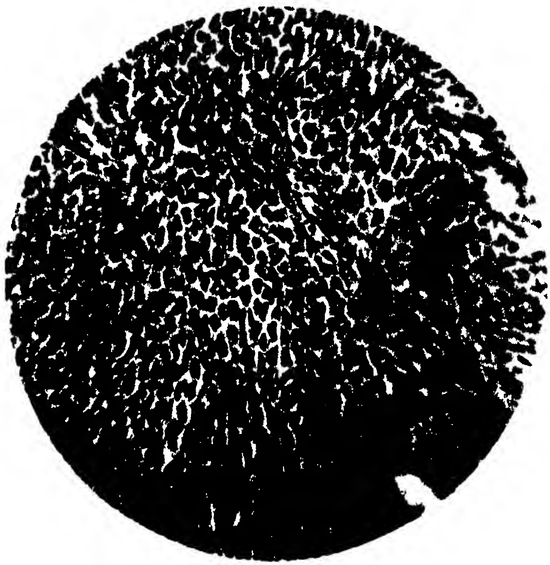

Fig. 11. Cells 2.5 cm from tip showing matured fibroblasts and endothelial cells. Obj 16 mm. Ocular 8 × comp.

Fig. 12. Cells 3.0 cm from tip showing matured fibroblasts a few of which have have atrophied. Obj 16 mm. Ocular 8× comp.

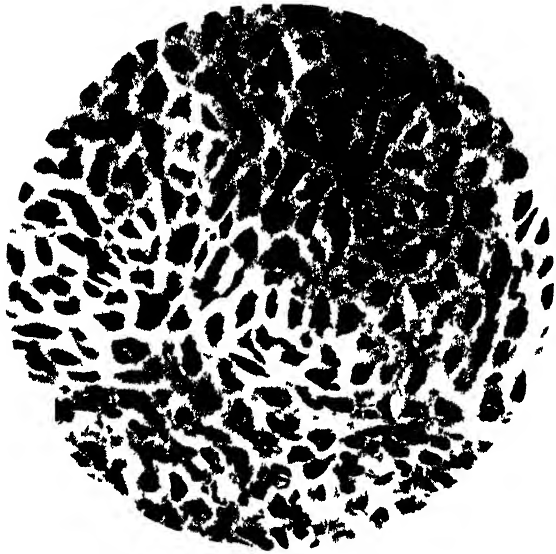

Fig. 43. Cells 3.5 cm. from tip showing marked atrophy of some fibroblasts and separation of the cells. Obj. 4 mm. Ocular 8× comp.

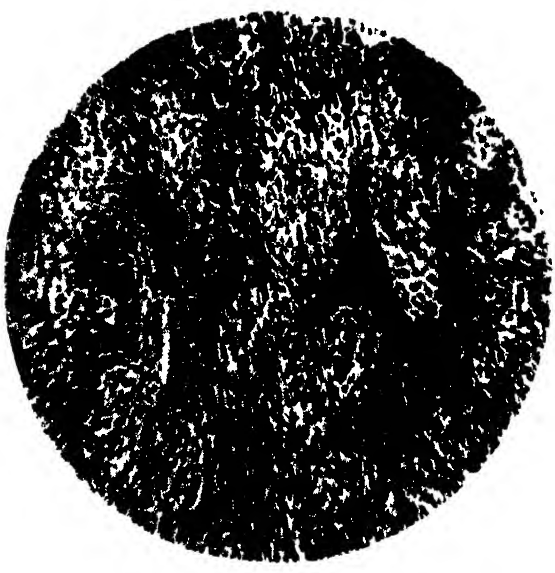

Fig. 44. Cross section 2.5 cm. from tip. Osteoblasts proliferating from periphery to centres of ossification. Obj. 16 mm. Ocular 8× comp.

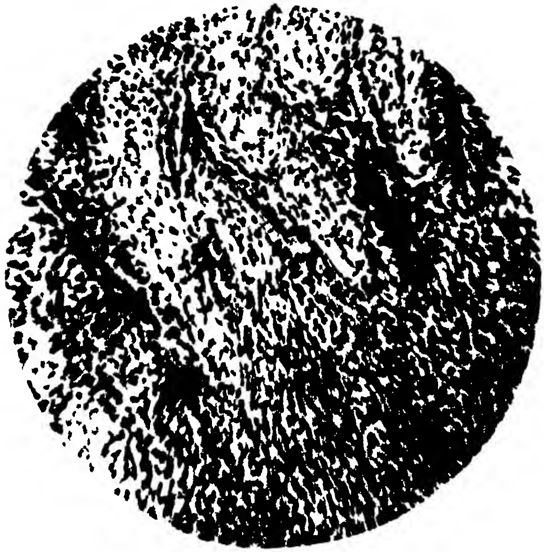

Fig. 15. Cross section 3 cm. from tip. Osteoblasts proliferating from periphery to centres of ossification. Obj. 16 mm. Ocular 8 comp.

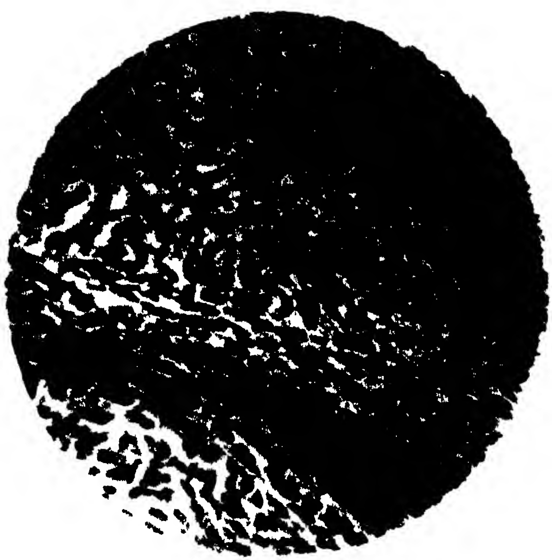

Fig. 16. Section 3.0 cm. from tip. Peripherally derived osteoblasts around centre of ossification. Obj. 4 mm. Ocular 8 comp.

Fig 47 Cross section 3 5 cm from tip Osteoblasts proliferating from periphery to centres of ossification Obj 16 mm Ocular 8 X comp

Fig 48. Longitudinal section 4 cm from tip showing proliferation of peripherally derived osteoblasts and lacunae in centres of ossification. Obj 16 mm. Ocular 8 X comp

Fig. 49. Longitudinal section 5 cm. from tip showing proliferation of peripherally derived osteoblasts. Obj. 16 mm. Ocular 8 × comp.

Fig. 50. Cross section 5.0 cm. from tip showing proliferation of osteoblasts and mature osteoblasts between blood channels and trabeculae. Obj. 16 mm. Ocular 8× comp.

Fig. 51. Showing fibrillar structure of cap continuous with fibers of velvet. Obj 16 mm. Ocular 8× comp. Stain: Modified Del Rio Hortega's Silver Carbonate Method.

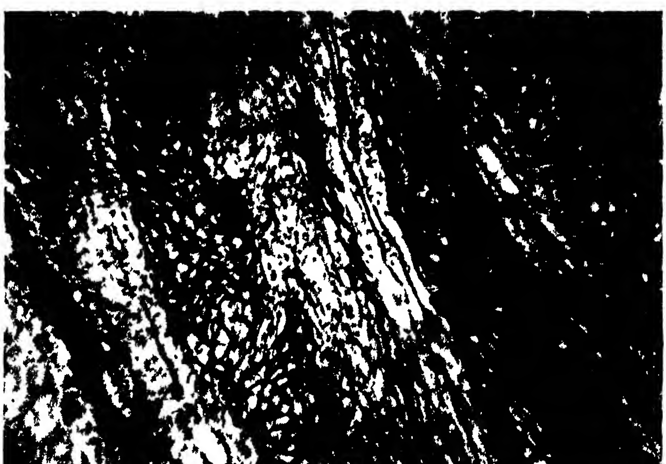

Fig. 52. Showing fibrillar ground-work 2.0 cm. from tip and longitudinal fibrillae of blood channels. Obj. 4 mm. Ocular 8× comp. Stain: Modified Del Rio Hortega's Silver Carbonate Method.

Fig. 53. Fibrillar network 3 cm from tip. Obj. 4 mm. Ocular 8× comp. Stain: Modified Del Rio Hortega's Silver Carbonate Method.

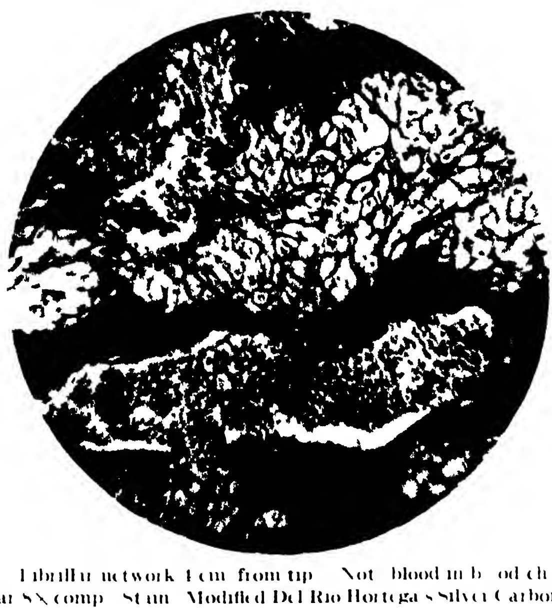

Fig. 54. Fibrillar network 4 cm from tip. Note blood in blood channels. Obj. 4 mm. Ocular 8× comp. Stain: Modified Del Rio Hortega's Silver Carbonate Method.

Fig. 55. Cross section 3.5 cm. from tip showing atrophy of fibroblasts derived from the cap and slight centres of ossification.

Fig. 56. Cross section 5.0 cm. from tip showing definitive osteoblasts evolved from peripheral undifferentiated connective tissue. Obj. 4 mm. Ocular 8 × comp.

A LIST OF ANTILLEAN REPTILES AND AMPHIBIANS

BY THOMAS BARBOUR

INTRODUCTION

Census makers are abroad in the world, far and wide, and this year, 1930 is a fitting time to list the species of West Indian Reptiles and Amphibians which I, for one, believe to be valid. This is a point on which no two persons are at present ready to agree but workers are nearer unanimity today than ever before. I have made this little list as concise as possible. I have avoided synonymys and citations and have not quoted authorities. I simply give a list of the species which at this moment I believe to be worthy of recognition and a list which I believe to be complete. For errors I am, therefore, wholly to blame and no doubt a number will be found.

There are some exquisite and precious zoologists who do not deign to recognize in the check-list anything but the most plebeian form of zoological choremanship This, indeed, may be true. Nevertheless even those of the élite, οἱ αἱρετοι or οἱ ἀλισκόμενοι as earlier colleagues would perchance have called them, admit the usefulness of such lists. Generally speaking utility is the poorest touchstone to apply to research, but it is the only test to determine the worthwhileness of compilations.

The few short remarks which I have added beneath each name may aid some future workers who become inquisitive concerning the status of species, as of today.

I published, not long ago, a little paper showing what the mongoose has accomplished in the way of reptile extirpation since its introduction. (Proc. N. Eng. Zool. Club, vol. 11 p. 73-85, 1930).

I have not included the fauna of Trinidad or Tobago in this list except as they support species which occur on the true Antillean islands. Nor do I include the islands off the South or Central American coast.

I have arranged the species in series endeavoring more or less to keep allied forms together. Everyone, however, knows that a linear list cannot be expected to express relationships beyond a certain point.

I have included introduced forms near their nearest native allies. I may not have the number of these by any means complete but they are uninteresting waifs at best in most cases. Many obviously erroneous records have been ignored.

SYSTEMATIC TABLE OF CONTENTS

A Class—AMPHIBIA

Order—*LORICATA*

Family—CROCODYLIDAE

Crocodylus rhombifer Cuvier 116
Crocodylus acutus Cuvier 116
Crocodylus intermedius Graves 116

Class AMPHIBIA

Order *SALIENTIA*

Family HYLIDAE

Hyla septentrionalis Boulenger

Cuba; also (perhaps accidentally) the Cayman Islands and Northern Bahamas.

A common species.

Hyla dominicensis (Tschudi)

Hispaniola.

A common ally of *Hyla septentrionalis.*

Hyla brunnea Gosse

Jamaica.

The common vicarious representative of *H. dominicensis* and *H. septentrionalis.*

Hyla vasta Cope

Hispaniola.

Formerly little known, now well studied by Noble. Not uncommon in some wet mountainous ravines in San Domingo.

Hyla lichenata (Gosse)

Jamaica.

Probably of the stock of *Hyla vasta* but well differentiated. This species has been studied by Dunn who finds that it lives in hollow limbs of trees. Its head is modified to close the opening.

Cf. *Bufo empusus* and the discussion of phragmotic modifications in amphibians and reptiles. Barbour Reptiles and Amphibians, Boston, Houghton Mifflin & Co., 1926, p. 73 et seg.

Hyla pulchrilineata Cope

Hispaniola.

Formerly considered to be related to the *Hyla arborea* series, but erroneously. It may have Jamaican affinity with *Hyla wilderi* or it may be anthocthonously developed from *Hyla dominicensis* as Dunn suspects.

Hyla wilderi Dunn

Jamaica.

I collected this species commonly in 1909 but did not realize that the specimens were adults of a new species, not young of the common *Hyla brunnea.* It is found in the "wild pines," epiphytic bromeliads.

Hyla marianae Dunn

Jamaica.

Apparently not common anywhere and found in the highlands only.

Hyla heilprini Noble

Hispaniola.

Found by Noble in 1922, among stones in the ravines of mountain torrents in Pacificador Province, San Domingo.

Hyla squirrella Latreille

Southeastern United States; Stranger's Cay, Northern Bahamas.

Found in the Bahamas in 1903 by Allen, Bryant and Barbour. Accidental, no doubt.

Hyla rubra Daudin

South America and St. Lucia.

Reported years ago, 1891, from St. Lucia where it was doubtless accidentally introduced. We have no recent information as to its persistence.

Family BUFONIDAE

Bufo longinasus Stejneger

Western Cuba.

Known from the type only, taken during the summer of 1900 on the bank of a stream in the lowlands near El Guamá, a ranch near Pinar del Rio city. This species and the two following vicarious forms are not closely related to any existing toad. Many characters, however, suggest an affinity with *Bufo quercicus*. It is possible that all may have descended from some common ancestral type which occurred in what is now Central America.

Bufo dunni Barbour

Central Cuba.

Found abundantly after heavy rains in the mountains between Trinidad and Cienfuegos.

Bufo ramsdeni Barbour

Eastern Cuba.

Found by C. T. Ramsden only. Taken after heavy rains in isolated localities in the mountains about the Guantanamo basin.

Bufo peltacephalus Tschudi

Cuba.

Generally distributed but nowhere abundant. I believe that this species may be a surviving representative of the same stock from which *Bufo punctatus* Baird & Girard is descended.

Bufo empusus (Cope)

Cuba.

This is the Cuban representative of the *Bufo lemur* series. It occurs in widely scattered colonies of burrows. I have described its mode of occurrence at some length elsewhere. (Mem. Mus. Comp. Zool. 44, 1914, p. 242).

Bufo gutturosus Latreille

Hispaniola.

A much more common species than its Porto Rican ally.

Bufo lemur Cope

Porto Rico.

For forty years after its description but six of these toads were found. Modern collectors have recently secured a larger number. The four toads of this series may be allied to *Bufo canaliferus* Cope of the mainland of Central America.

Bufo turpis Barbour

Virgin Gorda.

The type is still unique. No other toad has ever been found in the Virgin Islands. It is very closely allied to *Bufo lemur* of Porto Rico.

Bufo marinis (Linne)

Jamaica, Bermuda, Barbados, St. Lucia, St. Kitts, Martinique, Nevis and Montserrat, introduced. Native of South and lower Central America.

A favorite species for haphazard introduction.

Family LEPTODACTYLIDAE

Eleutherodactylus auriculatus (Cope)

Cuba.

Dunn believes that this form is confined to the Guantanamo region.

Eleutherodactylus sonans Dunn

Cuba.

An arboreal form of Central Cuba allied to *E. auriculatus* of Eastern Cuba.

Eleutherodactylus portoricensis Schmidt

Porto Rico.

The representative of *E. auriculatoides* and *E. auriculatus*.

Eleutherodactylus auriculatoides Noble

Hispaniola.

Found by Noble in bromeliads along the Constanza-Jarabacoa trail, Paso Bajito, Santo Domingo.

Eleutherodactylus jamaicensis Barbour

Jamaica.

Taken at Mandeville in 1908, it has since been found in many other parts of the Island.

Eleutherodactylus weinlandi Barbour

Hispaniola.

A lowland species widely distributed in the eastern areas.

Eleutherodactylus richmondi Stejneger

Porto Rico.

A virgin forest form allied to *E. weinlandi* of Hispaniola and *E. lentus* of St. Thomas.

Eleutherodactylus lentus Cope

St. Thomas and St. Croix.

This still seems to be a common species. Its subterranean habits protect it against capture by the mongoose.

Eleutherodactylus schmidti Noble

Hispaniola.

Another of Noble's interesting discoveries at Paso Bajito. He says it is allied to *E. weinlandi* of the Dominican Republic and to *E. richmondi* of Porto Rico and so on to *E. lentus* of the Virgin Island.

Eleutherodactylus inoptatus (Barbour)

Hispaniola.

A large species which barks when handled and which is found in both Haiti and San Domingo. This by far the largest and finest species of the genus was discovered by Dr. W. M. Mann at Diquini, Haiti. It resembles superficially *E. insignitus* from the Sta. Marta Mts. of Colombia. This may be a good case of convergence.

Eleutherodactylus ruthae Noble

Hispaniola.

Noble described this species from Samana, R. D., and he considers it allied to *E. inoptatus*.

Eleutherodactylus martinicensis (Tschudi)

Saba, Montserrat, St. Kitts, St. Eustatius, St. Martins, Martinique, Guadeloupe, Jamaica (introduced near Kingston about 1890).

This little frog is so easily carried about that its true original distribution will never be known.

Eleutherodactylus johnstonei Barbour

Grenada; ? St. Vincent (? extinct).

Said to have been brought to Grenada from Barbados about 1885. It has recently appeared in Bermuda.

All that can be said is that this frog from the south end of the Antillean chain is different from that found in the north and middle portions. Doubt will always exist as to the true original ranges of these two species. They have been carried far and wide with plants and have from time to time appeared in hot houses in Europe and North America.

Eleutherodactylus brittoni Schmidt

Porto Rico.

Another from the forest on El Yunque.

Eleutherodactylus abbotti Cochran

Hispaniola.

Said to be a very common species throughout San Domingo.

Eleutherodactylus montanus Schmidt

Hispaniola.

A species from the Cibao Mountains.

Eleutherodactylus minutus Noble

Hispaniola.

On ferns in palm thickets on trail near Paso Bajito, San Domingo; fide Noble.

Eleutherodactylus orcutti Dunn

Jamaica.

Another of the recently found and apparently very local forms; from Arntully in St. Thomas Parish.

Eleutherodactylus cunctator Dunn

Jamaica.

Known only from Arntully in St. Thomas Parish.

Eleutherodactylus nubicola Dunn

Jamaica.

Found high in the Blue Mountains, 3000-5100 feet.

Eleutherodactylus luteolus (Gosse)

Jamaica.

Common and widely distributed; from Port Antonio to Montego Bay.

Eleutherodactylus gossei Dunn

Jamaica.

Widespread at altitudes of about 1000 feet.

Eleutherodactylus pantoni Dunn

Jamaica.

The largest Jamaican species.

Eleutherodactylus junori Dunn

Jamaica.

Known only from Spaldings, Clarendon Parish, altitude 2900 feet.

Eleutherodactylus cundalli Dunn

Jamaica.

A woodland species, as yet but little known.

Eleutherodactylus grabhami Dunn

Jamaica.

A small species with a wide range, as to both area and altitude.

Eleutherodactylus varleyi Dunn

Cuba.

Known from Central and Eastern Cuba and said by Dunn to be allied to *E. minutus* and *E. abbotti* of San Domingo.

Eleutherodactylus atkinsi Dunn

Cuba.

A handsome species found throughout the Island.

Eleutherodactylus varians (Gundlach & Peters)

Cuba.

Known definitely only from Soledad, near Cienfuegos.

Eleutherodactylus eileenae Dunn

Cuba.

The "Kolin" of western and central Cuba.

Eleutherodactylus dimidiatus (Cope)

Cuba.

A widespread species.

Eleutherodactylus emiliae Dunn

Cuba.

Known only from the Mina Carlota, in the mountains not far from Cumanayagua, Sta. Clara Province.

Eleutherodactylus pinarensis Dunn

Cuba and Isle of Pines.

Known in Cuba from the Province of Pinar del Rio only.

Eleutherodactylus greyi Dunn

Cuba.

The largest Cuban species, so far known only from the mountains between Cienfuegos and Trinidad.

Eleutherodactylus brevipalmatus Schmidt

Cuba.

A form from the mountains of the Province of Oriente.

Eleutherodactylus sierrae-maestrae Schmidt

Cuba.

Another mountain species from eastern Cuba.

Eleutherodactylus ricordii (Duméril & Bibron)

Cuba and Bahamà Islands; S. Florida.

Found in all parts of Cuba and on New Providence, Abaco and Andros Island. It is now extending its range in Florida as I reported some years ago. It has now reached Gainesville. (Proc. Biol. Soc. Wash., 23, 1910, p. 100.)

Eleutherodactylus cuneatus (Cope)

Cuba and Isle of Pines.

Common in western and central Cuba.

Eleutherodactylus gundlachii Schmidt

Cuba.

An eastern mountain form. I originally described this species but used the specific name *plicatus*, which proved to be preoccupied.

Eleutherodactylus casparii Dunn

Cuba.

Another species of the Trinidad Mountains.

Eleutherodactylus gryllus Schmidt

Porto Rico.

A minute, highland species.

Eleutherodactylus locustus Schmidt

Porto Rico.

Another species from El Yunque forest.

Eleutherodactylus cramptoni Schmidt

Porto Rico.

A rare species from the mountain forest on El Yunque Peak.

Eleutherodactylus antillensis (Reinhardt & Lütken)

Porto Rico, St. Thomas, Tortola, Vieques.

A widespread and common species.

Eleutherodactylus wrightmanae Schmidt

Porto Rico.

A form "probably confined to the coffee belt and the wet forest above it."

Eleutherodactylus unicolor Stejneger

Porto Rico.

From El Yunque.

Eleutherodactylus monensis (Meerwarth)

Mona Island.

Eleutherodactylus flavescens Noble

Hispaniola.

From bushes along streams near La Bracita, found by Noble in 1922.

Leptodactylus fallax Müller

Dominica, St. Kitts, Guadeloupe, St. Lucia.

The giant "crapaud" has been recently separated specifically from the mainland *L. pentadactylus.* Now to be found on Dominica only. Elsewhere it has been exterminated by the mongoose. It may have occurred upon other islands even, than those recorded above. I am not convinced that it is really very distinct from the mainland "species".

Leptodactylus dominicensis Cochran

Hispaniola.

The San Domingan representative of *L. albilabris* of Porto Rico and the Virgin Islands.

Leptodactylus albilabris (Günther)

St. Thomas, St. Croix, Tortola, Anegada, Just van Dyke, Porto Rico, Vieques, Culebra.

This common form no doubt occurs on other islets in this general area.

Leptodactylus validus Garman

St. Vincent, Grenada, Venezuela.

There is a great question whether this form is distinct or identical with *L. caliginosus* from Brazil and just what the relationship may be with *L. labialis* or *L. melanonotus* from Central America.

Family BRACHYCEPHALIDAE

Phyllobates limbatus (Cope)

Cuba.

Locally abundant. This species has been separated from the mainland species of this genus, as Sminthillus, on a trivial skeletal character of divergence. It is, however, I now believe essentially a Phyllobates in all important respects except perhaps in life history. The species of "Sminthillus" described from Peru is quite certainly wholly unrelated to the Cuban form. I believe that we may generally agree that Sminthillus (type *limbatus*) is a straight synonym of Phyllobates. The Peruvian species in any case requires a new name, and may be called Noblella, type *N. peruviana* (Noble).

Class REPTILIA

Suborder *SAURIA*

Family GEKKONIDAE

Gymnodactylus fasciatus Duméril & Bibron

Martinique.

I know nothing of this species and have often wondered what it is. The type in Paris was said to be from the Plée Collection and taken at Martinique. The Plée Collections have caused endless confusion by having so often erroneous data as to locality. I suspect that I had done better to omit this species altogether.

Gonatodes albogularis (Duméril & Bibron)

Martinique, Curaçao.

This, another Plée type from "Martinique," may have come from almost anywhere in the Caribbaean basin. Many of the members of this genus are in confusion and await a reviser.

Gonatodes notatus (Reinhardt & Lütken)

Hispaniola.

Apparently a valid species which may be confined to Haiti. It seems to be rare.

Gonatodes fuscus (Hallowell)

Cuba and Central America.

This house lizard is known from the seaports of Santiago, Havana and Mariel, which is in constant schooner communication with Havana. I suspect the species was long since accidentally introduced into Cuba.

Phyllodactylus spatulatus Cope

Barbados.

Collected years ago, about 1861 in fact, by Dr. Theodore Gill. I have no recent information as to its status.

Hemidactylus mabouia (Moreau de Jonnés)

Cuba, Jamaica, Hispaniola, Porto Rico, St. Thomas, St. Croix, Just van Dyke, Tortola, Dominica, St. Lucia, St. Vincent, Barbados, Martinique, Grenada and the Grenadines; Northern South America.

This lizard, one frequenting the street lamps of towns and cities, is, I believe, accidentally introduced. It is rare in the Greater Antilles, and in Cuba very local.

Hemidactylus brookii Gray

West Africa; Hispaniola.

I believe this is another accidental introduction.

Thecadactylus rapicaudus (Houttuyn)

Saba south to Grenada, tropical South and Central America.

Nocturnal or crepuscular. Found under bark, behind shutters and in old buildings, also in the forest in crevices of rocks and sometimes under decaying vegetable trash. It is known from almost every single island, all indeed which have been in any completely explored.

Aristelliger praesignis (Hallowell)

Jamaica, Grand Cayman and Cayman Brac.

An abundant, if not actually common, species.

Aristelliger lar Cope

Hispaniola.

Apparently rather widely distributed. It has recently been collected in larger numbers than the earlier investigators uncovered.

Tarentola cubana Gundlach & Peters

Cuba and Bahamas.

Shy and retiring in rocky crevices this species is rarely seen. I suspect it to be widespread in the Bahamas though I have seen it from Andros and Exuma Islands only. In Cuba it is more common in the northeastern region than elsewhere.

Sphaerodactylus decoratus Garman

Bahama Islands.

Common on Andros, rare on New Providence. The type came from Rum Cay.

Sphaerodactylus gibbus Barbour

Bahama Islands.

Known only from the Exuma Cays.

Sphaerodactylus torrei Barbour

Cuba.

Known from the Province of Oriente only. It is not rare.

Sphaerodactylus cinereus Wagler

Cuba, Navassa, Hispaniola and extreme south Florida.

A common form in houses and in woodlands. It passes through a number of color phases during growth and the young and half grown were once thought to be distinct species and bore specific names, *elegans* and *intermedius*.

Sphaerodactylus oxyrrhinus Gosse

Jamaica.

A rare form but one widespread through the Island.

Sphaerodactylus difficilis Barbour

Hispaniola.

Common and widely distributed.

Sphaerodactylus notatus Baird

Florida Keys and extreme southern Florida, Cuba, Isle of Pines and Bahama Islands.

A very common house lizard. No doubt often carried about and rapidly extending its range.

Sphaerodactylus macrolepis Günther

St. Croix, St. Thomas, Tortola, Virgin Gorda, Anegada, Porto Rico, Vieques and Mona.

Widespread and common.

Sphaerodactylus richardsoni Gray

Jamaica.

A fine big form but one which is distinctly rare.

Sphaerodactylus becki Schmidt

Navassa.

I am not sure, judging from the second known specimen recently collected, that this species is really separable from *S. scaber* of Cuba.

Sphaerodactylus gilvitorques Cope

Jamaica.

I know nothing of this species. I have never found it; nor has any of our various collectors in Jamaica. The types were taken "during the forties" by Dr. Pennock of Philadelphia.

Sphaerodactylus nigropunctatus Gray

Cuba.

A rare species from Eastern Cuba.

Sphaerodactylus carticolus Garman

Bahama Islands.

Known from New Providence, Watlings Island and Rum Cay. No doubt it occurs in many other islands beside these.

Sphaerodactylus festus Barbour

Martinique.

Known from but few specimens but no doubt common.

Sphaerodactylus goniorhynchus Cope

Jamaica.

A very common woodland species.

Sphaerodactylus argus Gosse

Jamaica.

An excessively common species both in houses and out of doors.

Sphaerodactylus argivus Garman

Cayman Brac.

A derivative of *S. argus* of Jamaica. A fairly well defined species. It is apparently known from the type series only.

Sphaerodactylus anthracinus Cope

Bahama Islands.

Only known from Andros Island.

Sphaerodactylus copei Steindachner

Hispaniola.

A fine, big, rough scaled species which is rare and apparently confined to Haiti.

Sphaerodactylus scaber Barbour & Ramsden

Cuba.

Found in the hills of central Cuba.

Sphaerodactylus fantasticus Duméril & Bibron

Guadeloupe.

Very abundant.

Sphaerodactylus pictus Garman

St. Kitts.

Probably abundant.

Sphaerodactylus sputator (Sparrman)

St. Eustatius.

The types in Stockholm are the only specimens known.

No Sphaerodactli are as yet known from St. Martin, Saba, Redonda and other small islands in this neighborhood.

Sphaerodactylus elegantulus Barbour

Antigua.

An ally of *pictus* and *sputator*. Brilliantly banded when young and less ornamented in adult life — like so many of the curious little beasts.

Sphaerodactylus microlepis Reinhardt & Lütken

St. Lucia.

I know little of the status of this and several others of the Lesser Antillean forms.

Sphaerodactylus vincenti Boulenger

St. Vincent.

No information available.

Sphaerodactylus monilifer Barbour

Dominica.

Probably abundant but I have no real information about this species.

Family IGUANIDAE

Iguana rhinolopha Wiegmann

Central America and St. Thomas, Saba, St. Kitts, Dominica, St. Lucia, Grenada.

I am not certain of some of these records. A few may apply to the following species.

Iguana delicatissima Laurenti

St. Martin, St. Barts, Nevis, Guadeloupe, Martinique, swarming on Swan Island, Brazil.

Here again I am similarly uncertain. I believe both species have been widely carried about and introduced by the early Indians for food. They are well worth the trouble.

Chamaeleolis chamaeleontides (Dumèril & Bibron)

Cuba.

The most peculiar of all the offshoots from the Anoline stock. A rare species and beyond doubt a monotypic genus; in spite of several names applied with the idea of multiplying the forms.

Xiphocercus valenciennesii (Dumèril & Bibron)

Jamaica.

Not uncommon in woods and fruit plantations. It may be related to Phenocosaurus of Colombia or be simply a chance offshoot from Anolis in Jamaica and only fortuitously similar to the South American genus.

Chamaelinorops barbouri Schmidt

Navassa.

Not found during the careful exploration of Clench, Schevill and Rehder during January 1930. Possibly exterminated by introduced animals

Chamaelinorops wetmorei Cochran

Hispaniola.

The unique type is from near Miragoane, Haiti.

Deiroptyx vermiculata (Duméril & Bibron)

Cuba.

Bank of streams of Pinar del Rio Province, taking refuge in the water and hiding among submerged rocks and stones when pursued.

Deiroptyx bartschi Cochran

Cuba.

Long unrecognized but not rare in western Cuba.

Anolis equestris Merrem

Cuba and Isle of Pines.

The finest and largest species of the genus. Rather uncommon but wide ranging. Less common than its allies *A. garmani* of Jamaica and *A. ricordii* of Hispaniola and about equally abundant with *A. cuvieri* of Porto Rico. These are the "Giant Anoles" of the Antilles and they may be related to the *A. insignis* group of Central America.

Anolis cuvieri Merrem

Porto Rico, Vieques and Tortola.

A rather uncommon member of the series of "Giant Anoles."

Anolis ricordii Duméril & Bibron

Hispaniola.

One of the "Giant" series. Found throughout the whole Island and next to *A. garmani* of Jamaica the most abundant of the tribe.

Anolis garmani Stejneger

Jamaica.

The beautiful great green or barred "Venus Lizard" of Jamaica. A common woodland form by far the most abundant of the group of the "Giant Anoles."

Anolis porcatus Gray

Cuba and Isle of Pines.

A very abundant species. The "Chamaeleon" now sold iniquitously by thousands at "the circus." It has replaced its ally, our southern "Chamaeleon," *A. carolinensis* (Voight) in this hateful traffic.

Anolis maynardi Garman

Grand Cayman.

This extraordinary lizard, the most extreme member of the long-headed *A. porcatus-carolinensis* series, is by no means common.

Anolis brunneus Cope

Bahamas.

The most widespread Bahaman species, from Crooked Island to Abaco. A species of gardens and verandahs, frequenting broad leaved plants and resting often on the leaves.

Anolis longiceps Schmidt

Navassa.

Apparently the only species at present to be found in any number on this Island.

Anolis chloro-cyanus Duméril & Bibron

Hispaniola.

A widespread and not uncommon form.

Anolis mestrei Barbour & Ramsden

Cuba.

A rather rare species of the higher woods in the limestone hills of western Cuba. It belongs with *A. ahli* and *A. allogus*.

Anolis allogus Barbour & Ramsden

Cuba.

This fine form has a wide distribution in the mountains of eastern Cuba. Its ally in western Cuba is *A. mestrei*, in Central Cuba, *A. ahli*.

Anolis ahli Barbour

Cuba.

Confined to the mountains between Trinidad and Cienfuegos. It is related to *A. mestrei* and *A. allogus*. Not uncommon in high damp woods.

Anolis abatus Ahl

Cuba.

This species may be valid, it is more probably a synonym of *Anolis mestrei*.

Anolis bimaculatus Sparrman

St. Eustatius, St. Kitts and Nevis.

Abundant. A strictly arboreal species.

Anolis newtonii Günther

St. Croix.

I have never seen this species and know nothing about it.

Anolis evermanni Stejneger

Porto Rico.

A highland species which may be related to *A. leucophaeus* of Inagua. An abundant form.

Anolis krugi Peters

Porto Rico.

A little, well dispersed species belonging to what I call the rupicolous as against the arboreal Lesser Antillean series—viz. *A. wattsi*, *A. sabanus*, and allies.

Anolis acutus Hallowell

St. Croix.

This is still be an abundant form. I have just received a fine series.

Anolis wattsi Boulenger

St. Kitts, Nevis, St. Eustatius and Antigua.

A pretty little species found on the outcrops of igneous rock and, in so far as my experience goes, not in trees. It is one of the *A. acutus* allies.

Anolis forresti Barbour

Barbuda.

Only known from the types but obviously a small rock-inhabiting species most nearly allied to the species standing directly before it.

Anolis gundlachi Peters

Porto Rico.

Apparently an abundant species.

Anolis gingivinus Cope

St. Martins, St. Barts, Anguilla and St. Eustatius.
Common. A member of the series of small sized Lesser Antillean species.

Anolis sabanus Garman

Saba.
A most remarkably differentiated form, a rock lizard, pure and simple The males with fine leopard-like spotting. It is one of the *A. wattsi-A. acutus* tribe but very distinct and uniquely marked.

Anolis antiquae Barbour

Antiqua.
A beatiful and common arboreal species.

Anolis lividus Garman

Montserrat.
All the lizards are said still to be common on this Island.

Anolis barbudensis Barbour

Barbuba.
Known from the type only but no doubt common as are its relatives on Antigua and Nevis.

Anolis asper Garman

Marie Galante.
A bizarre and gorgeous species common on the old mango trees—about the only trees still standing over a large part of this hurricane stricken isle.

Anolis leachii Duméril & Bibron

Guadeloupe.
One of the large species. Found abundantly by Noble in 1914, it was rare after the fearful hurricane of Sept. 12, 1928.

Anolis terrae-altae Barbour

Les Saintes; near Guadeloupe.
A fine big species which Noble found abundant in 1914.

Anolis alliaceus Cope

Dominica.
I was surprised in 1929 to find that this species seemed much less conspicuous and common than its allies on other islands nearby. So much for what may have been a most erroneous conclusion drawn from the visit of a few days only. It is, however, by no means rare.

Anolis nubilus Garman

Redonda.

A beautiful great lizard; one of the finest in the genus. It is known only from the original series.

Anolis griseus Garman

St. Vincent.

This lizard was formerly abundant. It is now rare. It may have been more or less terrestrial and hence have been a prey to the mongoose.

Anolis richardii Duméril & Bibron

Grenada and Tobago.

A splendid great lizard; a strict tree dweller.

Anolis rubribarbus Barbour & Ramsden

Cuba.

Known only from a very few specimens from Puerto Cananova on the north coast of the oriental province.

Anolis quadriocellifer Barbour & Ramsden

Cuba.

Known only from the Cape San Antonio region of extreme western Cuba.

Cuba.

Anolis patricius Barbour

Only known from a series taken by Dr. Ramsden at Mina Piloto, near Sagua de Tanamo, northern coast of Oriente Province. The eastern representative of *A. quadriocellifer*.

Anolis cristatellus Duméril & Bibron

Porto Rico, Culebra, Vieques, St. Thomas, Anegada, Tortola, Virgin Gorda, Water Island and Mosquito Island.

A common and handsome species. It has been suggested that a separate genus be established for the fin-tailed species, but as a matter of fact this character appears in various phyla and it may not always be a token of relationship.

Anolis monensis Stejneger

Mona.

The local derivative of *A. cristatellus*. Apparently, like it, a common species.

Anolis alutaceus Cope

Cuba and Isle of Pines.

Known from all parts of the Island but nowhere abundant. A species of the low scrublands.

Anolis spectrum Peters

Cuba.

A not uncommon lizard in woodlands during the rainy season. It disappears completely during the dry portion of the year. It ties in with one of the *A. semilineatus*, *A. olsoni*, *A. hendersoni* series of Haiti as does also, I think, *A. alutaceus* and PERHAPS *A. cyanopleurus*.

Anolis cyanopleurus Cope

Cuba.

A marvelously beautiful species which Dr. Ramsden has rediscovered in the old type locality, the mountains about Guantanamo. I suspect from its habit that it may be largely terrestrial. It is said to be local and uncommon.

Anolis semilineatus Cope

Hispaniola.

An abundant, cursorial grass living form.

Anolis olssoni Schmidt

Hispaniola.

Apparently a not uncommon member of the group of slender terrestrial species long confused with *A. semilineatus* and allied to *A. spectrum* of Cuba.

Anolis hendersoni Cochran

Hispaniola.

A small terrestrial species mostly, if not wholly, from the western portion of the Island.

Anolis pulchellus Duméril & Bibron

Porto Rico, Vieques, Virgin Gorda, Tortola, Anegada, St. Thomas, St. Croix, Just van Dyke.

A common ground living species. Doubtfully recorded from Haiti.

Anolis poncensis Stejneger

Porto Rico.

A rare local species. One which is terrestrial and almost Norops-like in habit.

Anolis latirostris Schmidt

Navassa.

Known from the unique type only.

Anolis stratulus Cope

Porto Rico, Vieques, Culebra, St. Thomas, Tortole, Just van Dyke.

A common lowland species.

Anolis coelestinus Cope

Hispaniola.

I have seen this form from Haiti only and have no recent information to offer.

Anolis dominicensis Reinhardt & Lütken

Hispaniola and La Gonave Island.

This species is not uncommon in Haiti but seems to be rare on La Gonave. I secured a small series in 1929—but in a very dry time.

Anolis distichus Cope

Bahama Islands.

Common on the ceiba trees of New Providence Island. I think it occurs on other islands as well but upon trying to find why I have this impression I cannot lay hands on a bit of evidence. It may be confined to New Providence.

Anolis distichoides Rosén

Andros Island.

A poorly defined form replacing *A. distichus*. It is very abundant.

Anolis sagrei Duméril & Bibron

Cuba and Isle of Pines; probaly introduced in Jamaica and Belise.

The commonest Anolis and, as its range is wide in Cuba, perhaps this form has the largest species population in the genus. The commonest fence, house-wall and brush lizard in Cuba, by far.

Anolis ordinatus Cope

Bahamas.

Known from Turks Island to New Providence. Common everywhere. This is a derivative of the *A. sagrei* stock and only a moderately well defined species. It is much more distinct in life than in preserved form.

Anolis luteosignifer Garman

Cayman Brac.

Probably as abundant as it ever was.

Anolis longitibialis Noble

Beata Island.

The apparently rare but quite well defined local representative of the *A. cybotes* stock.

Anolis lineatopus Grey

Jamaica.

The common fence lizard of the dry Liguanea Plain about Kingston. It swarms here but occurs nowhere else, so far as anyone knows at present.

Anolis homolechis Boulenger

Cuba and Isle of Pines.

A widespread and not uncommon species found in wooded ravines or lowland woods and heavy scrub.

Anolis greyi Barbour

Cuba.

Only known from a small number taken in the town of Camaguey and in the Cubitas range of hills not far away.

Anolis doris Barbour

La Gonave.

I have only seen a very few specimens of this lizard, a contrast to its ally *A. cybotes*, which is very abundant in Haiti.

Anolis cybotes Cope

Hispaniola.

Common as are the allies of *A. sagrei* wherever they occur. This is one of a series of dominant and successful species.

Anolis angusticeps Hallowell

Cuba and Isle of Pines.

I consider this a really rare species in western Cuba where, however, it occurs quite widely. It is more abundant in the Isle of Pines.

Anolis oligaspis Cope

New Providence.

A rare representative of *A. angusticeps* of Cuba. It may occur also upon other islands. Much intensive herpetological work remains to be done in the central and southern Bahama Islands.

Anolis isolepis Cope

Cuba.

An excessively rare species. It occurs in the mountains of Oriente Province and apparently replaces *A. angusticeps*.

Anolis lucius Duméril & Bibron

Cuba.

The abundant lizard of the limestone cliffs and open caves of central Cuba from Matanzas and Santa Clara Provinces, especially.

Anolis argenteolus Cope

Cuba.

Found in the Province of Oriente. Far from rare, it occurs on rocks,

cliffs and often also on building walls and fences. I have taken it on the trunks of the great *Ficus nitida* (Sp. Laurél de la India) trees which used to stand in the Plaza at Santiago.

Anolis argillaceus Cope

Cuba.

I have never seen this species in life. Dr. Ramsden says it is not uncommon in the old coffee plantations high in the mountains about Guantanamo.

Anolis bremeri Barbour

Cuba.

A fine striking species, known only from the type which I took years ago at Herradura in Pinar del Rio Province.

Anolis loysiana Cocteau

Cuba.

A rare and bizarre little lizard. It is found sparingly all over Cuba on light colored tree barks. It is extraordinary like rough bark in appearance. Some believe that the genus Acantholis proposed to contain this species is really valid. It becomes more common during the summer rains, than it is in the dry season, our winter.

Anolis leucophaeus Garman

Inagua, Turks and Caicos Islands.

A common species. I have not seen it from Caicos but am told that the same Anolis occurs there that is so common on Grand Turk.

Anolis speciosus Garman

Marie Galante.

Known from Garman's types only. I did not find it in 1929.

Anolis marmoratus Duméril & Bibron

Desirade.

I know nothing of this form. Garman found it abundant in 1882.

Anolis roquet (Lacépède)

Martinique.

An abundant representative of the *A. vincenti-A. luciae* set of allied forms.

Anolis luciae Garman

St. Lucia.

Apparently like so many Antillean species whether from one reason or another much less common than formerly.

Anolis vincentii Garman

St. Vincent.

Like most of the reptiles of this Island this species is now rare. It may descend to the ground from time to time and so fall prey to the mongoose. I should have said that most of the species of this Island are extinct.

Anolis gentilis Garman

Grenada and the Grenadines.

A rather small inconspicuous lizard which is still abundant.

Anolis opalinus Gosse

Jamaica.

A rather rare, woodland species, most often seen in western Jamaica.

Anolis iodurus Gosse

Jamaica.

A beautiful and not uncommon little woodland species. It is found widely distributed on the Island.

Anolis grahami Gray

Jamaica.

Common in the woods of Eastern Jamaica.

Anolis conspersus Garman

Grand Cayman.

A derivitive of *A. grahami* of Jamaica. It is probably not rare.

Norops ophiolepis (Cope)

Cuba and Isle of Pines.

A common terrestrial species usually found hiding in the heavy tufts or bunches of pasture grasses.

Cyclura cristata Schmidt

White Cay, near Watlings Island.

A small colony in danger if not already lost.

Cyclura figginsi Barbour

Bitter Guana Cay, near Great Guana Cay, Exuma group.

This little colony is now, I learn, almost certainly exterminated.

Cyclura portoricensis Barbour

Porto Rico.

Extinct but relatively recent bones found in several caves.

Cyclura mattea Miller

St. Thomas.

Recently extinct, known from recent osseous remains only.

Cyclura pinguis Barbour

Anegada.

Excessively rare if not now gone.

Cyclura stejnegeri Barbour & Noble

Mona.

Another rare species. This may be the same as *C. cornuta.*

Cyclura nigerrima Cope

Navassa.

Extinct. I am not sure that this was really distinct from *C. cornuta*, in fact I rather doubt it, but material is lacking to settle the question.

Cyclura cornuta (Bonnaterre)

Hispaniola, La Gonave, Petit Gonave and Beata Island.

Persisting only in isolated colonies on the larger island but very common on Beata.

Cyclura collei Gray

Jamaica.

Almost extinct. There are a few on Goat Island, off the Bushy Park property and a few on the Cays about Montego Bay.

Cyclura carinata Harlan

Turks Island.

Abundant still on some Cays near Turks Island and in the Caicos group.

Cyclura nuchalis Barbour & Noble

Fortune Island.

Said now to be extinct.

Cyclura rileyi Stejneger

Two small Cays in the lagoon of Watlings Island.

A few are said to persist.

Cyclura inornata Barbour & Noble

U Cay in Allen's Harbor near Highborn Cay, Bahamas.

Once widespread, no doubt now extirpated through use by the negros for food. This was the only specimen which Maynard could find—a relict on a tiny islet.

Cyclura baeolopha Cope

Andros Island.

Reported to be considerably decreased in numbers.

Cyclura caymanensis Barbour & Noble

Cayman Brac and Little Cayman.

Reported still to be not uncommon.

Cyclura macleayi Gray

Cuba and Isle of Pines.

Rare. Persisting in only the wildest and most inaccessible districts.

Cyclura ricordii (Duméril & Bibron)

Hispaniola.

Long known from the type only, until rediscovered by Dr. W. L. Abbott. Now known to be not uncommon in a few scattered localities in San Domingo.

Leiocephalus carinatus Gray

Cuba, Isle of Pines, Bahamas and Cayman Brac.

Widespread about rocky shores, headlands and sea cliffs. So far as I am aware seldom or never seen inland, certainly never in Cuba. With its tail tightly curled over its back this lizard jumps and hops about its haunts in a most unreptilian-like manner. The Cayman Brac specimens may represent a separate form but material is too scant to be sure.

Leiocephalus melanochlorus Cope

Hispaniola.

Known from Jeremie in southwest Haiti to Puerto Plata in Northern San Domingo.

Leiocephalus schreibersii (Gravenhorst)

Hispaniola and Great Inagua.

A common species on Inagua and Haiti. We have not seen it from San Domingo.

Leiocephalus personatus Cope

Hispaniola.

Allied to *L. cubensis* it is apparently common and widespread over the whole Island. I SUSPECT *L. lherminieri* (Duméril & Bibron) to be a synonym of this species. It was said to have come from Trinidad and Martinique, L'herminier, and Plée collectors, but both these gentlemen caused confusion on more than one occasion by either labelling their material incorrectly or else by shipping the results of a visit to several islands home to Paris in one lot shipment, after receipt of which the whole consignment was entered in the records of the Jardin

des Plantes as having been *collected* at the point of shipment. This sort of thing has caused confusion for modern workers on a host of occasions.

Leiocephalus eremitus Cope

Navassa.

Not found by Beck or the Clench party last year. Cats and dogs, now feral, may be to blame for the disappearance of this and other species.

Leiocephalus cubensis Gray

Cuba and Isle of Pines.

The common lizard of the canefields. I believe that investigation will show it to be very highly beneficial in controlling insects which are injurious to the industry.

Leiocephalus psammodromus Barbour

Turks Island.

A common species and one which I at first called *L. arenarius* but found that that name had been obscurely given by Tschudi to a Peruvian species that apparently had escaped all notice by subsequent authors.

Leiocephalus varius Garman

Grand Cayman.

When on Grand Cayman three years ago, I could not find this species but that may have been owing to the terrific drought, widespread that year, over the whole Antillean region.

Leiocephalus virescens Stejneger

Green Cay, Bahamas.

Said still to be common.

Leiocephalus raviceps Cope

Cuba.

I once doubted the validity of this species but it seems to be really well defined and confined to Eastern Cuba.

Leiocephalus loxogrammus Cope

Rum Cay and Watlings Island, Bahamas.

This species will probably prove to be much more widespread than we now know it to be.

Leiocephalus macropus Cope

Cuba.

A species found abundantly throughout the Province of Oriente but so far as we now know not westward, of, let us say, a vertical line drawn north and south and passing about through Holguin.

Leiocephalus semilineatus Dunn

Hispaniola.

Known only from Thomazeau, Haiti.

Leiocephalus barahonensis Schmidt

Hispaniola.

Known only from the southeastern portion of San Domingo.

Leiocephalus beatanus Noble

Beata Island.

Common and the only representative of the genus which either Noble or I were able to find on the Island.

Leiocephalus vinculum Cochrane

Gonave Island, Haiti.

I visited Gonave in 1929 during a very prolonged drought and saw but one of this species. This does not mean that it may not be abundant.

Hispaniolus pratensis Cochran

Hispaniola.

Taken by Milles at St. Michel, Haiti.

Family ANGUIDAE

Celestus de la sagra (Cocteau)

Cuba.

A widespread but excessively rare and perhaps disappearing species.

Celestus rugosus Cope

Hispaniola.

Whether or not this species is really valid remains to be determined when more material comes to hand.

Celestus costatus (Cope)

Hispaniola.

This species may be the same as *C. occiduus* of Jamaica. These species all change greatly during growth and are rather in confusion taxonomically.

Celestus badius Cope

Navassa.

This species may still occur on Navassa. I have a specimen taken but a few years ago. It may be identical with *C. costatus*.

Celestus maculatus (Garman)

Cayman Brac.

A rather poorly defined but, I think, valid form apparently known from the type only.

Celestus occiduus (Shaw)

Jamaica.

A form which was once common and of which old adults reached a great size—like Tiliqua of Australia or Corucia of the Solomon Islands. No such giants now occur and the species is rare.

Celestus impressus Cope

Jamaica.

A smaller and commoner species than *C. occiduus* but still one of which we know very little.

Celestus pleii (Duméril & Bibron)

Porto Rico.

A species which is much like its Cuban congener but apparently even now rather less rare.

Sauresia sepoides Gray

Hispaniola.

I once sunk this genus into Celestus but the concensus of opinion is that I was wrong. It seems really to be not uncommon.

Wetmorena haetiana Cochran

Hispaniola.

Known from a few examples taken by Wetmore in the higher regions of the La Selle massif in Haiti.

Family XANTUSIIDAE

Cricolepis typica (Gundlach & Peters)

Cuba.

Confined to the area, of a few square miles at most, between Belig and Cabo Cruz, Oriente, Cuba.

Family TEIIDAE

Kentropyx intermedius Gray

South America. Trinidad, Barbados.

What was probably this species was formerly common on Barbados but it is now wholly extinct on that Island. Garman named (*K. copei*) but did not describe this species. I have not material to settle the validity of the name.

Ameiva aquilina Garman

St. Vincent and Grenada.

Extinct on St. Vincent but still persisting on Grenada.

Ameiva fuscata Garman

Dominica.

Owing to the absence of the mongoose this, the finest of all the Antillean Ameivas, is still a common species.

Ameiva cineracea Barbour & Noble

Guadeloupe.

Extirpated except for a few individuals which persist on the tiny islets off the coast.

Ameiva atrata Garman

Redonda.

A black species superficially like *A. corvina* and living under similar conditions. It has not been collected recently, probably only because the Island is now almost never visited.

Ameiva pluvianotata Garman

Montserrat.

I have just learned that this species is still very common all over the Island.

Ameiva erythrops Cope

St. Eustatius.

Peters found this form abundant in 1922.

Ameiva griswoldi Barbour

Antigua and Nevis.

Extinct on Nevis, it is also almost gone on Antigua where it persists only right in the town of St. John in yards and gardens.

Ameiva erythrocephala (Daudin)

St. Kitts.

Extirpated from the wilder parts of the Island; it still occurs in the gardens and yards of Basseterre. Here it is safe from the mongoose.

Ameiva garmani Barbour

Anguilla.

This species is still abundant. It is closely allied to *A. pleii*.

Ameiva pleii Duméril & Bibron

St. Barts and St. Martin.

We have again no recent information to indicate that this is not still an abundant species.

Ameiva corvina Cope

Sombrero.

A black form which, like so many Lacertids and some species of Cnemidophorus and indeed another Ameiva, has assumed this peculiar coloration as a result of isolation on a very small, arid, sunbaked and rocky island.

Ameiva polops Cope

St. Croix.

Extinct, but very few specimens have been preserved.

Ameiva wetmorei Stejneger

Porto Rico.

Rare and confined to the arid zone about Guanica. Schmidt defines its range as the limestone hills about Ensenada and on Caja de Muertos Island. This species also belongs to the *lineolata, maynardi, polops* stock, which thrives only in arid areas.

Ameiva maynardi Garman

Great Inagua.

A beautiful species of the *A. lineolata* series.

Ameiva alboguttata Boulenger

Mona Island.

According to recent accounts still abundant. Closely related to the Porto Rican form next following.

Ameiva exsul Cope

St. Thomas, Water Island, St. John, Vieques, Anguilla, St. Croix and Porto Rico.

New exterminated on St. Thomas. I have always doubted the St. Croix record. It is common where it still occurs at all.

Ameiva vittipunctata Cope

Hispaniola.

A very beautiful and apparently not very common form.

Ameiva taeniura Cope

Hispaniola.

When Dr. Noble and I prepared our Revision of Ameiva in 1915, I think I was principally to blame for concluding that this species was the young of *A. lineolata*. Miss Cochran has shown that this is untrue and that the species is perfectly valid.

Ameiva lineolata Duméril & Bibron

Hispaniola.

Widespread and abundant.

Ameiva chrysolaema Cope

Hispaniola.

A very common and widely spread species.

Ameiva thoracica Cope

Bahama Islands.

Now known to be widespread in the northern and central portion of the Bahama archipelago.

Ameiva dorsalis Gray

Jamaica

Formerly abundant, then, after the mongoose came, pretty well reduced—almost exterminated. Now recovering slightly in numbers in the cities and settlements where the mongoose population is kept in hand.

Ameiva auberi Cocteau

Cuba and Isle of Pines.

Nowhere abundant but very widely distributed. Perhaps most frequently seen along railway enbankments.

Ameiva barbouri Cochran

La Gonave Island.

Taken only by Eyerdam in 1927. I did not find it when on La Gonave in 1929.

Ameiva beatensis Noble

Beata Island.

I found this species much less common that *A. abbotti* on a recent visit to Beata.

Ameiva abbotti Noble

Beata Island.

Common on this beautiful but generally uninhabited Island.

Ameiva navassae Schmidt

Navassa.

Known from the type only, taken by R. H. Beck in 1917. Not found by the last collectors in 1930.

Scolecosaurus alleni Barbour

Grenada.

A distinct and not uncommon species of the wet spice gardens. This little creature is most commonly found under heaps of half decayed cocoa pods.

Gymnophthalmus pleei Bocourt

St. Lucia and Martinique.

Extinct.

Whether *G. luetkenii*, also of Bocourt, from "St. Lucia" is really distinct or whether it ever came from St. Lucia will, in part, be solved by examination of the type. Only *pleei* was found on these two islands by Garman, who took a good series before it was exterminated.

Family AMPHISBAENIDAE

Cadea palirostrata Dickerson

Isle of Pines.

A very distinct and abundant species.

Cadea blanoides Stejneger

Cuba.

Rare and confined to Matanzas, Havana and Pinar del Rio Provinces.

Amphisbaena fenestrata Cope

St. Thomas, St. Croix and St. John.

I know of no recent information on the status of this species.

Amphisbaena bakeri Stejneger

Porto Rico.

Rare and local.

Amphisbaena caeca Cuvier

Porto Rico.

Not very uncommon.

Amphisbaena manni Barbour

Hispaniola.

This form seems to be about equally abundant with *innocens*.

Amphisbaena innocens Weinland

Hispaniola.

Not uncommon in Haiti.

Amphisbaena cubana Peters

Cuba.

Common in Central Cuba. Best found by following plows.

Amphisbaena caudalis Cochran

Grande Cayemite Isl., Haiti.

Known from but two examples taken by Eyerdam in 1927. It is allied to *A. innocens*.

Family SCINCIDAE

Mabuya aenea Gray

St. Vincent, Grenada and Trinidad.

Probably extinct on the first two and rare and disappearing in Trinidad.

Mabuya luciae Garman

St. Lucia.

Extinct.

Mabuya dominicana Garman

Dominica.

During a visit to Dominica during March, 1929, I saw several skincs in and about the Botanical Gardens at Roseau. I am told that they are not rare elsewhere.

Mabuya lanceolata Cope

Barbados.

Extinct.

Mabuya sp. indet.

Skincs occurred on Guadeloupe surely and probably on several other of the lesser Antilles from which they have disappeared without being described. There are skincs from Guadeloupe in the Paris Museum and perhaps preserved elsewhere.

Mabuya mabouia (Duméril & Bibron)

Martinique.

Extinct.

Mabuya spilonota Wiegmann

Jamaica.

Now excessively rare. It has lately been shown to feed on Sphaerodactyls.

Mabuya sloanii (Daudin)

St. Thomas, St. Croix, Porto Rico, Mona, St. John, Just van Dyke, and Culebra. Possibly also Hispaniola.

Much more material is needed to settle the status of many of the Antillean Mabuyas. At least two species are probably included under this name.

Suborder *OPHIDIA*

Family TYPHLOPIDAE

Typhlops tenuis Salvin

Mexico, Guatemala and Andros Island.

Rosén got what he called this species at Mastic Point in 1910. I have never felt very sure that it was not an undescribed form wrongly identified.

Typhlops rostellatus Stejneger

Porto Rico.

Seems to be related to *T. dominicana*. Perhaps other species remain to be uncovered in the Lesser Antilles.

Typhlops pusillus Barbour

Hispaniola.

Not uncommon in Haiti.

Typhlops dominicana Stejneger

Dominica and Guadeloupe.

The specimens from Martinique should belong here, one would suppose, rather than to *T. jamaicensis*. More material is highly desirable from any of the islands.

Typhlops sulcatus Cope

Navassa.

May not really be a valid species. It has not been found by the most recent collectors.

Typhlops jamaicensis (Shaw)

Jamaica, St. Thomas, Porto Rico and Martinique.

This is a strange and anomalous distribution. Either these species have been carried far and wide by chance or some future revision based on more material will be desirable. No reptile has this distribution naturally. With more material available from St. Thomas and perhaps St. Croix it is not unlikely that *T. richardii* Duméril & Bibron, type locality St. Thomas, may be reestablished.

Much aid has been derived from Miss Cochran's recent synopsis of this group of blind snakes.

Typhlops monensis Schmidt

Mona Island.

A little known member of the *T. lumbricalis* series. The species is not

very sharply defined. Only two specimens are known and more material is desirable and no doubt still obtainable.

Typhlops lumbricalis (Linne)

Cuba, Hispaniola, Andros, New Providence and Abaco.

Common everywhere and no doubt fortuitously introduced into the Bahamas.

Family LEPTOTYPHLOPIDAE

Leptotyphlops albifrons (Wagler)

Watlings Island, Antigua, Grenada and with a wide range in Tropical America.

This tiny burrowing snake has an erratic distribution and has probably been carried about by primitive man, being occasionally introduced with material intended for garden planting.

Leptotyphlops bilineata (Schlegel)

Martinique, St. Lucia, Guadeloupe and Barbados.

This, another tiny species, may have a considerably wider range among the islands than we now know.

Family BOIDAE

Epicrates angulifer Bibron

Cuba and Isle of Pines.

Formerly common everywhere, now confined to the wilder regions although individuals occasionally stray into the cultivated areas. The great extension of cane cultivation has decimated this species. Every cane cutter carries a machete all the time and uses it on every snake.

Epicrates subflavus Stejneger

Jamaica.

I had supposed this species gone in Jamaica itself until a recent letter from Mr. Frank Cundall of Kingston tells me that one from the southeast part of the Island was recently brought to the Institute of Jamaica alive. It persists on Goat Island off the south coast in small numbers.

Epicrates striatus (Fischer)

Hispaniola and Andros and New Providence in the Bahamas.

This boa is rather rare in Haiti and San Domingo but quite abundant in the Bahamas.

Epicrates monensis Zenneck

Mona.

A very little known species but one which I believe to be most closely allied to *E. fordii*.

Epicrates gracilis (Fischer)

Hispaniola.

I have never seen a specimen of this form in all the Haitian material which has passed through my hands. As described it has a very peculiar and unique color pattern but modern material would be very welcome.

Epicrates fordii (Günther)

Hispaniola.

More information concerning this species will be awaited with interest. Is it well differentiated from *E. gracilis* and *E. chrysogaster*?

Epicrates chrysogaster (Cope)

Turks Island.

Of this form I have no recent information. It is related to the little boas of Mona and Hispaniola, *E. fordii* or *E. gracilis*.

Epicrates inornatus (Reinhardt)

Porto Rico.

Now a really rare species and one which is related to the large boas of Cuba, Jamaica and Hispaniola.

Boa grenadensis Barbour

Grenada.

I may not have been justified in separating this form from *B. cookii*. I am, however, inclined to believe that it is fairly well differentiated and stabilized.

It is not very rare.

Boa hortulana Linne

St. Vincent, Grenada, The Grenadines and Trinidad, widespread on the mainland.

The species still occurs on Grenada and may, being arboreal, persist on St. Vincent. This, however, I am inclined now to doubt.

Constrictor orophias (Linne)

St. Lucia, Dominica.

The "tête chien" is rare on St. Lucia but still occurs—and even occasionally at least eats a mongoose. On Dominica it is less uncommon. There is a Zoological Park (Phila.) record for St. Kitts which I believe to be incorrect, captive snakes get carried far and wide and dealers convey notoriously inaccurate locality records. There are also records from Trinidad but my friend, Mr. Urich, a most competent resident authority, told me that the species does not occur in Trinidad. It is confined to two islands only.

Tropidophis maculatus (Bibron)

Cuba and Isle of Pines. Found sparingly in Western Cuba and the Isle of Pines.

I am following Miss Stull's conclusions in the taxonomy of this genus. I am not wholly convinced of the relationships implied but her work has been most painstaking and is based on all available material.

Tropidophis maculatus jamaicensis Stull

Jamaica.

Excessively rare, almost extinct, since the introduction of the mongoose.

Tropidophis maculatus haetianus (Cope)

Hispaniola.

Not uncommon all over the Island.

Tropidophis pardalis pardalis (Gundlach)

Cuba and Great Abaco Island.

This is a most unlikely distribution. Artificial introduction is possible but most improbable. Convergence to identity or persistence of a type on Abaco, which has differentiated on other Bahama Islands from a once widespread form is a scarcely satisfactory explanation either.

Tropidophis pardalis canus (Cope)

Inagua and Eleuthera Islands.

This species seems to be common where it occurs. It may also be found on others of the southern islands.

Tropidophis pardalis curtus (Garman)

New Providence, Bahamas.

A common form. It occurs under stones of walls and in the rocks heaped about the orange trees. Since it at times sallies forth after heavy rains it is locally called "thunder snake." Like all its congeners it is nocturnal.

Tropidophis pardalis androsi Stull

Andros Island.

Apparently abundant but I have never happened to see a specimen.

Tropidophis pardalis bucculentus (Cope)

Navassa.

Known from but three specimens, it has not been found by recent expeditions.

Tropidophus wrighti Stull

Cuba.

Known, so far as I am aware, from the type only. This was taken by Charles

Wright the botanist who collected for a long time in the Guantanamo Basin and, I think, nowhere else in Cuba.

Tropidophis melanurus (Schlegel)

Cuba.

The largest member of the genus, reaching a length of nearly a yard. It is abundant and widespread. It feeds on frogs, lizards and birds. Although more inclined to be arboreal than the other species of the genus, it is equally nocturnal and perhaps the most abundant of them all.

Tropidophis semicinctus (Gundlach & Peters)

Cuba and Isle of Pines.

Widespread but distinctly uncommon.

Family COLUBRIDAE

Natrix compressidauda Kennicott

Cuba, Florida Keys, extreme southwestern Florida.

My finding this species on the north coast of Cuba established the specific identity of the excessively rare Cuban Natrix and relegated several long questioned names to a definite synonymy.

Tretanorhinus variabilis Duméril & Bibron

Cuba.

Not uncommon in fresh water ponds and rivers. A nocturnal species. Its mainland ally *T. nigroluteus* is rather partial to mangrove swamps.

Tretanorhinus insulae-pinorum Barbour

Isle of Pines.

This species seems to have regularly 19 rows of scales while the Cuban snakes have 21. This is, at first sight, a trivial character but one which is apparently really diagnostic.

Drymobius boddaerti (Sentzen)

St. Vincent, Grenada and having elsewhere a vast neotropical distribution.

Extinct on St. Vincent and very rare in Grenada.

Uromacer oxyrhynchus Duméril & Bibron

Hispaniola and Isle Tortue.

A form found all over the Island, i. e. both Haiti and San Domingo. I have seen it from Port au Prince and Samana.

Uromacer frenatus (Günther)

Hispaniola and Isle Tortue.

I have only seen specimens from Haiti and know little of the abundance or distribution of this species.

Uromacer catesbyi (Schlegel)

Hispaniola and La Gonave.

A widespread but rather rare species.

Uromacer scandax Dunn

Isle Tortue, near Haiti.

An abundant ally of *U. catesbyi.*

Uromacer dorsalis Dunn

La Gonave Island.

Apparently a derivative of the Haitian *U. frenatus.*

Hypsirhynchus ferox Günther

Hispaniola.

A common widespread species, and one which is strictly nocturnal and oviparous.

Alsophis anomalus (Peters)

Hispaniola.

I have but little information to give concerning this species. Dr. G. M. Allen took one at Port au Prince in 1919. I have received no other recent specimen.

Alsophis sanctorum Barbour

Les Saintes Is. near Guadeloupe.

No doubt abundant still.

Alsophis sibonius Cope

Dominica.

With no mongoose on this island, the species should be abundant still. There are still great areas of wild land on Dominica.

Alsophis leucomelas (Duméril & Bibron)

Guadeloupe and Marie Galante.

Extinct on both islands. This may have been the species reported from Montserrat but it is more probable that this Island supports an undescribed form—if snakes are still to be found.

Alsophis sanctae-crucis Cope

St. Croix.

Extinct.

Alsophis melanichnus Cope

Hispaniola.

We await more informatiom concerning this snake with great interest. Its rarity in the collections which have come before me is perhaps indicative that it is fast disappearing.

Alsophis rijgersmaei Cope

St. Martins.

No herpetologist has visited St. Martins in recent years.

Alsophis cinereus Garman

St. Barts. and Anguilla.

Abundant in Anguilla but of St. Barts. we have no recent news.

Alsophis variegatus (Schmidt)

Mona Island.

Still probably abundant.

Alsophis portoricensis (Reinhardt & Lütken)

Porto Rico, Desecheo and Caja de Muertos Island.

A distinctly rare form.

Alsophis anegadae Barbour

Anegada.

I still feel that this form warrants recognition as valid. Its peculiar pattern is characteristic of every Anegada specimen which I have seen, even though it occurs very sporadically elsewhere, where other patterns are the place mode.

Alsophis antillensis (Schlegel)

St. Thomas, St. John, Virgin Gorda and Porto Rico.

Extinct on St. Thomas, rare on Porto Rico, elsewhere abundant.

Alsophis rufiventris (Duméril & Bibron)

Saba, St. Kitts, St. Eustatius and Nevis.

Still abundant on Saba and St. Eustatius but extinct on the other two islands. This may have been the form which occurred on Antigua but which became extinct before any specimens were ever secured.

Alsophis vudii Cope

Bahama Islands.

This racer is common on most of the middle group of Bahama Islands:—

New Providence, Eleuthera, Long Island, Green Cay, the Exuma Cays, and no doubt upon many others.

Alsophis fuscicauda Garman

Cayman Brac.

I do not feel certain of the status of this species until much more material is secured.

Alsophis caymanus Garman

Grand Cayman.

I have never seen sufficient material to decide whether this form is really different from that of Cuba.

Alsophis angulifer Bibron

Cuba and Isle of Pines.

A very common species in all open plains, pastures and savannas.

Dromicus andreae Reinhardt & Lütken

Cuba.

A common snake at pastures and open fields.

Dromicus nebulatus (Barbour)

Isle of Pines.

Another common form. It is closely related to the foregoing species, indeed closely similar specimens occur also in extreme eastern Cuba. We should probably recognize three races or abandon this name.

Dromicus callilaemus Gosse

Jamaica.

Small and more retiring. this species is not so near extermination as *L. ater*. Nevertheless it is a distinctly rare snake.

Dromicus ater Gosse

Jamaica..

Very rare indeed. A species which has suffered fearful ravages from the mongoose.

Dromicus juliae Cope

Dominica.

Probably still not uncommon.

Dromicus melanotus (Shaw)

Grenada, Trinidad and Venezuela.

Extinct apparently on Grenada but common elsewhere.

Dromicus perfuscus Cope

Barbados.

Extinct.

Dromicus mariae (Barbour)

Marie Galante.

Extinct.

Dromicus boulengeri (Barbour)

St. Lucia.

Extinct.

Dromicus cursor (Lacépède)

Martinique.

Extinct.

Dromicus anegadae Barbour

Anegada.

We have no recent information concerning this form but no reason to suppose that it is not still abundant.

Dromicus exiguus Cope

St. Thomas, St. John and Culebra.

Extinct on St. Thomas, it is probably not uncommon on the other islands.

Dromicus stahli (Stejneger)

Porto Rico.

Still not uncommon, widely distributed and confined to this Island.

Dromicus tortuganus (Dunn)

Isle Tortue, near Haiti.

Another well marked form of which, however, but two specimens have been taken, so far as I am aware.

Dromicus alleni (Dunn)

La Gonave Island.

A distinct and striking island form.

Dromicus parvifrons niger (Dunn)

Hispaniola.

This form inhabits most of San Domingo and I have found it on Beata Island.

Dromicus parvifrons protenus (Jan)

Hispaniola.

A common widespread form. Known from many localities in northern and central Haiti and the higher plateau of San Domingo.

Dromicus parvifrons parvifrons (Cope)

Hispaniola.

One of several races which appear to be common, reasonably well localized in southwest Haiti and probably valid.

Arrhyton taeniatum Günther

Cuba.

An uncommon species, like its fellow, found by day under stones or while plowing. At night it is sometimes met with abroad.

Arrhyton vittatum (Gundlach & Peters)

Cuba.

I now consider that there are but two species of this genus peculiar to Cuba. Several other names have been given, as I believe to individuals variants only. These snakes are close allies of Contia of the mainland.

Clelia cloelia (Daudin)

Dominica, St. Lucia, Grenada, Trinidad and tropical America generally.

This species is surely extinct in St Lucia, probably excessively rare on Grenada and its status on Dominica is still, no doubt, unchanged. I have never, however, seen or heard of recent specimens from any of the islands. Nevertheless, I think the records are really based on valid wild caught specimens.

Pseudoboa neuweidii (Duméril & Bibron)

Grenada, Trinidad and with a wide range in tropical America.

Garman took three examples on Grenada during the Blake Expedition about 1883. So far as I can learn it has never been taken before or since.

Ialtris dorsalis (Günther)

Hispaniola.

A large and uncommon species which has been found in both Haiti and San Domingo. It seems to have no close allies among Antillean reptiles and to be very rarely collected indeed.

Family CROTALIDAE

Bothrops atrox (Linne)

Martinique and St. Lucia.

What ever may be the origin of the Fer-de-lance's appearance on these islands, one thing Amaral has definitely proved,—the snake is the common wide ranging form of tropical America.

Order *CHELONIA*

Family TESTUDINIDAE

Pseudemys rugosa (Stahl)

Cuba, Jamaica, Hispaniola and Porto Rico.

I am not yet convinced that Schmidt's *P. stejnegeri* is valid nor am I by any means sure that the many local ideas as to multiplicity of species have any foundation in fact but I am often too conservative and hence wrong in such matters. Every Cuban *guajiro* believes that there is more than one species in Cuba.

Order *LORICATA*

Family CROCODYLIDAE

Crocodylus rhombifer Cuvier

Cuba and Isle of Pines.

Found in the Zapata Swamp in Cuba and no doubt still also in the Cienaga of the Isle of Pines. Specimens over six feet long are less often seen now than a generation ago.

Crocodylus acutus Cuvier

Cuba, Jamaica and Hispaniola; as well as Florida and Central America.

Crocodylus intermedius Graves

Orinoco Basin.

Accidental in Grenada, 6 Sept. 1910.

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DIGITAL EPIPHYSES AND CARPAL BONES IN THE GROWING INFANT FEMALE GORILLA WITH SITTING HEIGHT, WEIGHT AND ESTIMATED AGE*

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(Figs. 57 to 72 incl.)

It is the purpose of the writer to present the results of some observations on growth in the infant female gorilla based upon a study of four dead and one living specimen. Each of the specimens is apparently referrable to Gorilla gorilla.

The observations have been confined to the growth changes in the bones of the hand as revealed by means of a radiographic examination, and to the sitting height, weight, dentition, and the estimated age. As the chronological age is estimated it naturally follows that it is subject to correction.

The Material.

The material observed consists of four dead specimens and one living female gorilla, "Janet Penserosa." Their ages range from about 9 to 42 montns, and the sitting height (Crown-rump) from 37.5 to 63.5 centimeters. Janet Penserosa, the living specimen, is at the New York Zoological Park and at the present time appears to be in good physical condition.

Method of Presentation.

The observations will be presented in eight arbitrary stages of physical growth based upon the material observed. Starting with the smallest and youngest, each specimen will be described

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separately in the order of its sitting height and dentition. Observations which will serve to show growth changes in the same living individual were made upon Penserosa at four successive periods of time. In conclusion a summary of the observations will be tabulated in a composite table.

SPECIMEN NO. 1.

History.

The preserved body of this specimen (C. A. 1105) is in the collection of the Department of Comparative Anatomy at the American Museum of Natural History.

This young gorilla was captured by natives in the Cameroon of West Central Africa sometime during the spring of 1928 and was brought to Duala on the west coast of Central Africa. It was purchased at this port by a sea captain and taken on board a freight steamer to Brooklyn, N. Y., arriving at the latter port about July 22, 1928. During the voyage at sea, about twelve weeks, its food consisted of bananas (plantain) and diluted condensed milk. It had apparently become infected on board ship, since at the time of arrival it was suffering from a "common cold," according to the history given by the ship's captain. The captain had treated the suffering baby gorilla for a "cold" with home remedies and simple cough mixtures for about a week, after which the writer was called to examine the sick gorilla. On the night of July 29, 1928, an emaciated infant female gorilla was seen gasping for breath, with a mucopurulent discharge from the eyes and nostrils. Its gums were tender and swollen as the result of teething. The pharynx was congested and contained a mucopurulent exudate. Respiration was labored and painful. On auscultation increased sibilant bronchial tones were heard while on percussion dullness over the upper right lobe was present, with tenderness and pain in the lower parts of the chest wall. A diagnosis of broncho-pneumonia and pleurisy was made. Since the infant gorilla was very weak and unable to move about or sit up, a very unfavorable prognosis was made. It died the next morning, on July 30, 1928. Cause of death: Broncho-pneumonia and complications following a "common cold."

No autopsy was performed, but instead the remains were sent to the Department of Comparative Anatomy at the American Museum of Natural History in New York City, where it is now known as C. A. 1105. It is hoped that the viscera will be examined for gross pathological changes whenever the specimen may be dissected. It is believed that this is the youngest and

smallest specimen of an infant female gorilla in the United States.

The weight of its body at the time of death was 8½ pounds, or 3.86 kg. Its sitting height was 37.5 cm. Schultz[1] has reported as follows on this preserved specimen: "The preserved body of a small gorilla at the American Museum of Natural History (C. A. 1105) has eight incisors and four molars and weighs 4.5 kg. . . . its sitting height measures only 368 mm. and its head length 115 mm. as compared with the corresponding dimensions of Famelart's gorilla, etc." The writer wishes to call attention to an apparent discrepancy in the weight of the specimen as given by Schultz, i. e., 4.5 kg. and the weight of 3.86 kg. as recorded in this paper. This difference in weight can readily be explained by stating that the weight of 3.86 kg. was made before the specimen had been injected and placed in preserving fluid.

Since this gorilla was emaciated and evidently underweight as the result of disease, its weight cannot be considered as normal.

TABULATION OF OBSERVATIONS ON GORILLA NO. 1.

Estimated Age	9 to 12 months.
Sitting Height	37.5 cm. (According to Schultz, 36.8 cm.)
Weight	3.86 kg. (8½ pounds.)
Dentition	12 teeth. 4 upper and 4 lower incisors; 2 upper and 2 lower premolars.

Radiographic Record of the bones of the hand (Figs. 57-58).

Radius	Slight bowing.
Ulna	Relatively straight.
Distal Epiphyses of Radius	Visible in right and left hand.
Distal Epiphyses of Ulna	Visible in right hand only.
Carpal Bones	Os Capitatum (Magnum) and Os Hamatum (Unciform) visible.
Proximal Epiphyses of First Metacarpal	None visible.
Distal Epiphyses of Metacarpal Bones	Spherical and porous in appearance, and present in 2-3-4. The third is the largest.
Proximal Epiphyses First Phalanx	2-3-4 visible.
Proximal Epiphyses Second Phalanx	None visible.
Proximal Epiphyses Third Phalanx	None visible.

The above observations represent the stage of growth and development of the parts examined at the time of this gorilla's death.

Specimen No. 2.

History.

An infant female gorilla was obtained from natives by the captain and steward of a freight steamer at a port on the west coast of Central Africa on May 28, 1930. It was a very young specimen, which was teething at the time of purchase and had been quite ill during the sea voyage. The diet consisted of diluted whole dried milk and bananas. During the trip it was kept in a hot, poorly ventilated room, with one chimpanzee as a companion. This specimen arrived at Brooklyn, New York, on the night of August 5, 1930. Mr. Ellis S. Joseph, an animal importer and dealer, saw the weak, ailing infant gorilla on the night of August 6, 1930, and received permission to take it to his home for medical treatment. He described it as being in a state of exhaustion since it was panting for air in the hot, stifling atmosphere of a cabin room which had been fumigated. A denuded area the size of a half dollar, caused by the bite of the chimpanzee companion, was found on the left side of the head over the parietal bone.

The writer was called and saw the ailing infant gorilla, named "Trixie," at ten o'clock at night. It was found lying on its back in a weakened condition, unable to get up except with the greatest difficulty, when it would attempt to sit up only to fall to one side from sheer weakness. It seemed to be most comfortable lying on its back. Respiration was irregular, at first deep and labored, then gradually becoming weaker and almost fading out, then the respiration would become deeper again. A slight mucopurulent discharge was present from both eyes and nostrils, indicating the presence of a "common cold." Reddened tender gums with teeth in the process of eruption were present, indicating that the milk dentition was being completed.

A diagnosis of myocardial degeneration resulting from exhaustion and a "common cold" was made. Prognosis was very unfavorable as the gorilla was practically in a moribund state. There were several attacks of cardiac weakness during the night, with severe dysponea. Artificial respiration was resorted to twice with only slight temporary relief. At six o'clock in the morning of August 7, 1930, the creature died without a struggle during an attack of cardiac failure.

No autopsy was performed. The body was embalmed with 10% formalin. The writer is indebted to Mr. Ellis S. Joseph

for permission to have radiographs made and to make the observations tabulated below.

The embalmed body was received by Dr. Adolph Schultz of Johns Hopkins University from Mr. Joseph on November 12, 1930, at the New York Zoological Park hospital.

TABULATION OF OBSERVATIONS ON GORILLA NO. 2.

Estimated Age	14 to 16 months.
Sitting Height	41 centimeters.
Weight	4.66 kg.
Dentition	20 teeth. All incisors (8) and first premolars (4) completely erupted. The canines (4) and 2 upper second premolars in process of eruption. The two lower second premolars erupted.

Radiographic Record of the bones of the hand. Volar aspect. (Figs. 59-60).

Radius	Bowing present.
Ulna	Relatively straight.
Distal Epiphyses of Radius	Right and left visible.
Distal Epiphyses of Ulna	Right and left visible. (Left is larger than right.)
Carpal Bones	Os Capitatum (Magnum) visible. Os Hamatum (Unciform) visible.
Proximal Epiphyses of First Metacarpal	Both visible, one in each hand. (Small).
Distal Epiphyses of Metacarpal Bones	Large, spherical and porous. All four visible. 2-3-4-5.
Proximal Epiphyses First Phalanx	2-3-4-5. Flat, ovoid, webbed discs.
Proximal Epiphyses Second Phalanx	2-3-4. Flat, ovoid, webbed discs.
Proximal Epiphyses Third Phalanx	None visible.

SPECIMEN NO. 3.

History.

The third infant female gorilla of this series belongs to Dr. J. H. McGregor of Columbia University, from whom permission to examine it was obtained. He secured this young specimen in the Cameroon district at Vimili in West Central Africa during December, 1929. It was suffering from an attack of pneumonia, to which it succumbed in January, 1930. After embalming, the remains were brought to New York.

TABULATION OF OBSERVATIONS ON GORILLA NO. 3.

Estimated Age	16 to 18 months.
Sitting Height	43.5 centimeters.
Weight estimated	5.2 kg.*
Dentition	20 teeth. Full set milk teeth.

Radiographic Record of the bones of the hand. (Figs. 61-62.)

Radius	No record.
Ulna	No record.
Distal Epiphyses of Radius	Radiograph poor.
Distal Epiphyses of Ulna	Radiograph not clear.
Carpal Bones	Os Capitatum (Magnum), Os Hamatum (Unciform).
Proximal Epiphyses of First Metacarpal	One visible in each hand.
Distal Epiphyses of Metacarpal Bones	Spherical and webbed 2-3-4-5 visible.
Proximal Epiphyses First Phalanx	All visible as ovoid discs. 2-3-4-5.
Proximal Epiphyses Second Phalanx; Proximal Epiphyses Third Phalanx	On account of the contraction of the hands and hardening by formalin, the radiograph is not satisfactory.

SPECIMEN NO. 4.

History.

The body of the fourth specimen in this series is in the collection of the Department of Comparative Anatomy of the American Museum of Natural History in New York City and is labelled C. A. 1216. On account of the rufous color of the hair it is apparently referrable to Gorilla gorilla castaniceps.

It arrived on board a freight steamer, from a port on the west coast of Central Africa, at Brooklyn, New York, about July 1, 1929, and was obtained by a dealer in animals. The dealer had it about ten days, attempting to cure a profuse diarrhoea from which the gorilla had apparently been suffering during the voyage and after its arrival in Brooklyn. The writer saw the ailing infant female gorilla during the late afternoon of July 11, 1929, and found it to be extremely emaciated, anemic and weak, with a profuse diarrhoea and virtually moribund. Diagnosis: Enteritis—exact cause not determined; probably parasitic.

The prognosis was very unfavorable. Death occurred before midnight. As the remains were sent to the American Museum of Natural History, no autopsy was made.

*The weight of the embalmed specimen is 13¼ pounds and by allowing 2 pounds for the weight of the preserving fluid, its weight is estimated at 11½ pounds or 5.2 kg.

TABULATION OF OBSERVATIONS ON GORILLA NO. 4.

Estimated Age	24 to 30 months.
Sitting Height	53 centimeters.
Weight	(22 pounds) 10.9 kg. (Underweight-emaciated.)
Dentition	20 teeth. Full set of milk teeth. The canine teeth were quite large and protruded beyond the incisors.

Radiograph Record of the bones of both hands. (Figs. 67-68).

Radius	No record.
Ulna	No record.
Distal Epiphyses of Radius	Visible and definite in right and left hand.
Distal Epiphyses of Ulna	Right and left visible.
Carpal Bones	Os Capitatum (Magnum), Os Hamatum (Unciform), Os Navicular (Scaphoid), Os Triquetrum (Cuneiform) Os Multangular Major (Trapezium).
Proximal Epiphyses of First Metacarpal	Both present—very definite—one in each hand.
Distal Epiphyses of Metacarpal Bones	Spherical and webbed. 2-3-4-5 all visible and very definite.
Proximal Epiphyses First Phalanx	1-2-3-4-5. Ovoid, flat, webbed discs visible in both hands.
Proximal Epiphyses Second Phalanx	2-3-4-5. Ovoid, flat, webbed discs.
Proximal Epiphyses Third Phalanx	1-2-3-4-5. Ovoid, flat, webbed discs.

SPECIMEN NO. 5.

The fifth specimen of this series is the young female gorilla at the New York Zoological Park, known as "Janet Penserosa."

History.

Early in the summer of 1928, Rev. W. Reginald Wheeler sailed from the port of Duala situated on the west coast of Central Africa, with three baby gorillas (two females and a male) and a baby white-faced female chimpanzee. The gorillas were apparently referrable to Gorilla gorilla, the chimpanzee to *Pan chimpanzee.*

They had been in captivity for about three months before leaving Duala for New York via France. Their food consisted of milk from a nursing bottle, some bananas and white bread.

Two of the gorillas died and were buried at sea on the way from Duala to Bordeaux while the remaining infant female gorilla suffered from a "cold" and a digestive disturbance. As

soon as they arrived at Bordeaux both the gorilla and the chimpanzee were taken to the Jardin des Plantes in Paris, where they were nursed for several days while arrangements were being made to bring them to New York.

During the night of October 30, 1928, they landed at Pier 59, North River, on board the S. S. *Olympic* of the White Star Line. At 10:30 A. M. the next morning, October 31, 1928, an emaciated sick infant gorilla and chimpazee were received by Mr. William White Niles, Secretary of the New York Zoological Society, in order that they might be properly taken care of and protected.

Since both of the apes were in a very poor condition, suffering from the effects of the journey, a severe cold and an unsightly skin disease (dermatitis), they were placed in charge of the writer by Dr. W. Reid Blair, Director of the New York Zoological Park.

At noon they were taken from the pier and arrived at the Hospital in the New York Zoological Park at one o'clock. Examination revealed that both were extremely emaciated and suffered from an intense itch accompanying Dermatitis which caused them to scratch themselves incessantly. Their skin was completely covered with rough, dry, scaly, encrusted tenaceous masses of a honey-like, purulent character. A mucopurulent discharge from both eyes and nostrils was present. The eyelashes were stuck together with a purulent mass while the borders of the lids were granular. The conjunctivae were reddened and the eyes contained small flaky, purulent masses. In spite of their condition both apes were fairly active. The gorilla would refuse to come to anyone and would bite, squirm and cry if anyone attempted to separate her from the chimpanzee. She clung firmly to the chimpanzee and the chimpanzee in turn "mothered" and protected the baby gorilla. The gorilla weighed 17¼ pounds (7.84 kg.). The chimpanzee weighed 18 pounds (8.18 kg.).

The right nostril of the gorilla was completely occluded and the borders of both nostrils were eroded. A denuded, ulcerated area was present on the right thigh, and other parts of the body were tender. An examination of the mouth was very difficult due to the resistance of the gorilla, which would fight by biting and screaming. Its scream resembled the cry of an irritated angry child. All of the incisor and canine teeth were visible, and since the canine teeth were present it is very probable that she was in possession of a full set of 20 milk teeth. The height of the canine teeth was not much above that of the incisor teeth.

Comfortable quarters in one of the sanitary cages at the Hospital were provided for the patients, with fresh clean straw

as bedding. They were fed some oranges and bananas soon after arrival.

The occluded nostrils were cleared with cotton and a mild antiseptic solution, while their eroded margins were covered with some carbolated petrolatum.

There was some improvement until December 26, 1928, when bronchitis and bronchopneumonia developed and lasted until the middle of January, 1929. From that period on improvement was steady, as indicated by the weight record.

Table showing estimated age and weight record of infant female Gorilla "Janet Penserosa."

Age—Estimated	Date weighed	Weight—Kilograms
	10/31/28	7.84
20 months	11/ 9/28	8.93
	11/18/28	8.75
21 months	12/ 4/28	10.00
	12/26/28	10.34
22 months	1/15/29	10.34
23 months	2/ 5/29	10.68
	2/15/29	11.12
	3/28/29	11.13
25 months	4/13/29	11.47
26 months	5/ 1/29	11.70
	5/22/29	11.53
27 months	6/ 6/29	12.30
	6/24/29	12.95
28 months	7/ 5/29	13.18
	7/20/29	13.56
29 months	8/12/29	13.86
	8/30/29	14.10
30 months	9/10/29	15.00
	9/30/29	15.00
31 months	10/11/29	15.34
32 months	11/10/29	16.13
33 months	12/ 5/29	16.93
	12/27/29	17.60
34 months	1/21/30	18.30
35 months	2/13/30	18.86
36 months	3/ 7/30	19.54
	3/18/30	19.43
	3/30/30	19.77
37 months	4/21/30	20.45
38 months	5/ 9/30	20.34
39 months	6/ 2/30	21.36
40 months	7/10/30	22.20
	7/24/30	22.70
41 monthe	8/12/30	23.63
42 months	9/ 2/30	23.80
43 months	10/ 1/30	23.90
	10/20/30	24.09
45 months	12/ 9/30	24.65

Without going into the details of the care of the infant gorilla, it is of significance to note that it was irradiated with ultraviolet light from a mercury vapor lamp, at a distance of four to five feet for from 20 to 40 minutes daily during November and December, 1928 and the first five months of 1929. The only visible external effect seemed to be that the hair coat improved in appearance. As the skin on the gorilla's face is black no visible effect on its skin was observed. The bare face of the chimpanzee took on a tan as its skin is light and hairless. After May 28, 1929, irradiation was discontinued because they were kept out of doors each day from that date on.

Their nutritional requirements have been adequately provided for, as can be seen from their diet. The feeding schedule has remained the same from the time of arrival to the present date. Their food is plain and wholesome. It was not necessary to resort to the use of specially cooked or expensive foods for these apes at any time in order to maintain them in good condition.

Feeding Schedule.

8:00 A.M. Two to three cups diluted condensed milk.
Two teaspoonfuls whole dried milk.
One to two teaspoonfuls of a baby wheat food for flavoring.
Two raw eggs.

The above mixture is beaten with an egg beater and the gorilla is allowed to take as much as it desires.

9:00 A.M. Three teaspoonfuls of cod liver oil with one to two teaspoonfuls of a mixture of finely ground bone and blood meal.

12:30 P.M. Bananas with skins on. All anthropoid apes like to eat the inner white lining (the endocarp) of banana peels, especially of bananas which contain a tinge of green coloring in the skins. They prefer a banana which to the human has a slightly acrid taste rather than a sweet, fully ripe banana.
Oranges are an important item in the diet. Two or three oranges are fed daily. At times orange juice alone is given, about a cupful at a time.
Raw carrots.
Lettuce.
Boiled potatoes with skins on.

Simple rice pudding with a liberal supply of raisins.
Apples.
Celery.
Stale rye bread.
When available, the leaves and green burrs of the sweet gum tree (*Liquidambar styraciflua*) are enjoyed by the gorilla and chimpanzee. Young oak (*Quercus*) or wild cherry (*Betula lenta*) leaves are also relished.
At times they have eaten small quantities of cheese.
While they like peanuts we have not fed them except on rare occasions.

5:00 P.M. The evening meal is the same as the morning meal.

The following tabulations are made for comparison with the other observations in this series.

"JANET PENSEROSA." GORILLA NO. 5.
November 3, 1928.

Estimated Age	18 to 20 months (Brandes[2], Krogman[3] quoting Keith).
Sitting Height	No record for this date.
Weight	7.84 kg.
Dentition (Noback[4])	20 teeth. Since the canines were present a full set of milk teeth is assumed to have been present.

Radiographic Record of the bones of the right hand only. (Figs. 63-64.)

Radius	No record.
Ulna	No record.
Distal Epiphyses of Radius	Right visible.
Distal Epiphyses of Ulna	Right visible.
Carpal Bones	Os Capitatum (Magnum) and Os Hamatum (Unciform) show marked centers of ossification. Os Multangular major (Trapezium) and Os Triquetrum (Cuneiform) not so pronounced as first two and Os Navicular (Scaphoid) has a faint center of ossification.
Proximal Epiphyses of First Metacarpal	Visible in right hand. No record of left hand.
Distal Epiphyses of Metacarpal Bones	Spherical and webbed. Visible in 2-3-4-5.
Proximal Epiphyses of First Phalanx	Ovoid, flat, webbed discs in 2-3-4-5.
Proximal Epiphyses of Second Phalanx	Ovoid, flat, webbed discs in 2-3-4-5.
Proximal Epiphyses of Third Phalanx	Negative; not clear.

March 10, 1929.

Estimated Age	24 to 26 months.
Sitting Height	47.5 centimeters.
Weight	11.1 kg.
Dentition	20 teeth. A full set of milk teeth. The canines larger than the incisors.

Radiographic Record of the bones of the left hand. (Fig. 65.)

Radius	No record.
Ulna	No record.
Distal Epiphyses of Radius	Visible.
Distal Epiphyses of Ulna	Visible.
Carpal Bones	Os Capitatum (Magnum), Os Hamatum (Unciform), Os Triquetrum (Cuneiform), Os Navicular (Scaphoid), Multangular major (Trapezium).
Proximal Epiphyses of First Metacarpal	One visible.
Distal Epiphyses of Metacarpal Bones	Spherical and webbed. 2-3-4-5 visible.
Proximal Epiphyses of First Phalanx	Flat, ovoid, webbed discs. 1-2-3-4-5.
Proximal Epiphyses of Second Phalanx	Flat, ovoid, webbed discs. 2-3-4-5.
Proximal Epiphyses of Third Phalanx	Flat, ovoid, webbed discs in 2-3-4-5.

March 2, 1930.

Estimated Age	34 to 38 months.
Sitting Height	54.5 centimeters. March 18, 1929.
Weight	19.43 kg.
Dentition	24 teeth. The four first permanent molars erupted during February and March, 1930. None of the milk teeth have been shed.

Radiographic Record of the bones of both hands. (Figs. 69-70.)

Radius	Bowed.
Ulna	Relatively straight.
Distal Epiphyses of Radius	Visible in right and left hand.
Distal Epiphyses of Ulna	Visible in right and left hand.
Carpal Bones	Os Capitatum (Magnum), Os Hamatum (Unciform), Os Triquetrum (Cuneiform), Os Navicular (Scaphoid), *Os Multangular major (Trapezium), *Os Multangular minor (Trapezoid), *Os Lunatum (Lunar), *Os Pisiforme (Pisiform), *Os Centralia (Centrale).
Proximal Epiphyses of First Metacarpal	One visible in each hand and very definite.

*Appeared since March 10, 1929. The gorilla normally has eight carpal bones (Sonntag[6]), therefore the presence of nine carpal bones in Penserosa is apparently unusual.

March 2, 1930 (*Cont.*)

Distal Epiphyses of Metacarpal Bones........Spherical, webbed—2-3-4-5 visible. Fusion with metacarpal bones is visible in right hand.

Proximal Epiphyses First Phalanx............Flat, ovoid, webbed discs in 1-2-3-4-5.

Proximal Epiphyses Second Phalanx.. ....Flat, ovoid, webbed discs in 2-3-4-5.

Proximal Epiphyses Third Phalanx ....Flat, ovoid, webbed discs in 1-2-3-4-5.

July 25, 1930.

Estimated Age..............40 to 42 months.

Sitting Height............ ...63.5 centimeters.

Weight ....24 kg. September 3, 1930.

Dentition ....24 teeth.

1 set of milk teeth	20
First permanent molars	4
	24

Radiographic Record of the bones of both hands. (Figs. 71-72.)

Radius ....Bowed.

Ulna ....Relatively straight.

Distal Epiphyses of Radius...Visible in right and left hand.

Distal Epiphyses of Ulna.....Visible in right and left hand.

Carpal Bones ....No fusion between Centralia and Navicular.

Proximal Epiphyses of First Metacarpal.........Same as March 2, 1930.

Distal Epiphyses of Metacarpal Bones.. ......Spherical and webbed in 2-3-4-5. Fusion with metacarpal bones present in both hands.

Proximal Epiphyses First Phalanx............Flat, ovoid, webbed discs in 1-2-3-4-5.

Proximal Epiphyses Second Phalanx..... ....Flat, ovoid, webbed discs. 2-3-4-5.

Proximal Epiphyses Third Phalanx ....Flat, ovoid, webbed discs. 1-2-3-4-5.

LENGTH, SITTING HEIGHT AND SPAN.
"Janet Penserosa."

	Length Crown-Heel	Sitting Height Crown-Rump	Span Lying on back—arms outstretched.
May 18, 1929	72 cm.	47.5 cm.	106 cm.
March 3 ~~18~~, 1930	86 cm.	54.5 cm.	122 cm.
September 3, 1930	No record.	63.5 cm.	130 cm.

The following composite table on pages 150-151 contains a summary of the observations on the appearance of centers of ossification for the carpal bones and epiphyses in the hands of five infant female gorillas as determined by radiographic examination.

SUMMARY.

1. All the carpal bones (9), in the wrists of the living female gorilla under observation, were present before the fourth year. One other female gorilla, about five years of age, which will be reported on later, has been radiographed and all of its (8) carpal bones were present.

2. The development of the carpal bones, as shown in this study is very rapid in comparison with the human hand where the carpal bones are not normally present until about the tenth to the twelfth year. (Baldwin[6]).

3. The epiphyses of the bones of the hand appeared very early. Fusion had begun to take place between the metacarpal bones and their distal epiphyses at about the third year, the same time that the first permanent molars appeared.

4. The first permanent molar teeth (six-year molars of man) appeared at about the third year.

5. The total body weight of the living infant female gorilla increased steadily from 7.84 kg. on October 31, 1928, to 24.09 kg. on October 20, 1930. Its weight on arrival was less than the average weight of a one year old human female but after two years the weight was greater than the average weight of an eight year old child. (Davenport[7]).

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"Briefly summarizing the results of our investigations we may use the following data to determine or fix the age (Altersstufen) of the gorilla, the lower values to be used for the female."

Age		Weight	Dentition
1	year	6 to 7 kg.	20 milk teeth, canines still short.
1½	"	9 to 12 kg.	Canines and 2 milk molars grow to their full height.
2	"	15 to 18 kg.	M_1 erupts, and grows to full height.
2½	"	20 to 23 kg.	Shedding of incisors.
3	"	26 to 30 kg.	M_2 erupts, premolars shed.
4	"	40 to 50 kg.	Canines shed, M_3 erupts, color change in the hair,
5	"	70 to 80 kg.	particularly in the dorsal region.
6	"	80 to 100 kg.	

Dr. Gustav Brandes, Director of the Dresden Zoological Garden, in a communication to the writer, believes Penserosa to be six months younger than her estimated age. He bases his estimate on the assumption that the first permanent molar erupts in the gorilla at 2½ years of age, as indicated in his formula quoted above.

Krogman states that "the deciduous teeth, completely erupted, according to Keith, by the end of the second year in the anthropoids, erupt, variably, in the order of central and lateral incisors, first and second (pre?) molars, and canine. The first molar is the first permanent tooth to erupt, presumably at or shortly before the age of four years."

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A SERIES OF SIXTEEN RADIOGRAPHS SHOWING THE DEVELOPMENT
OF THE DIGITAL EPIPHYSES AND CARPAL BONES IN THE GROWING INFANT FEMALE GORILLA

Radiographs made by L. T. Le Wald, M.D.,
Professor of Roentgenology, Medical College, New York University

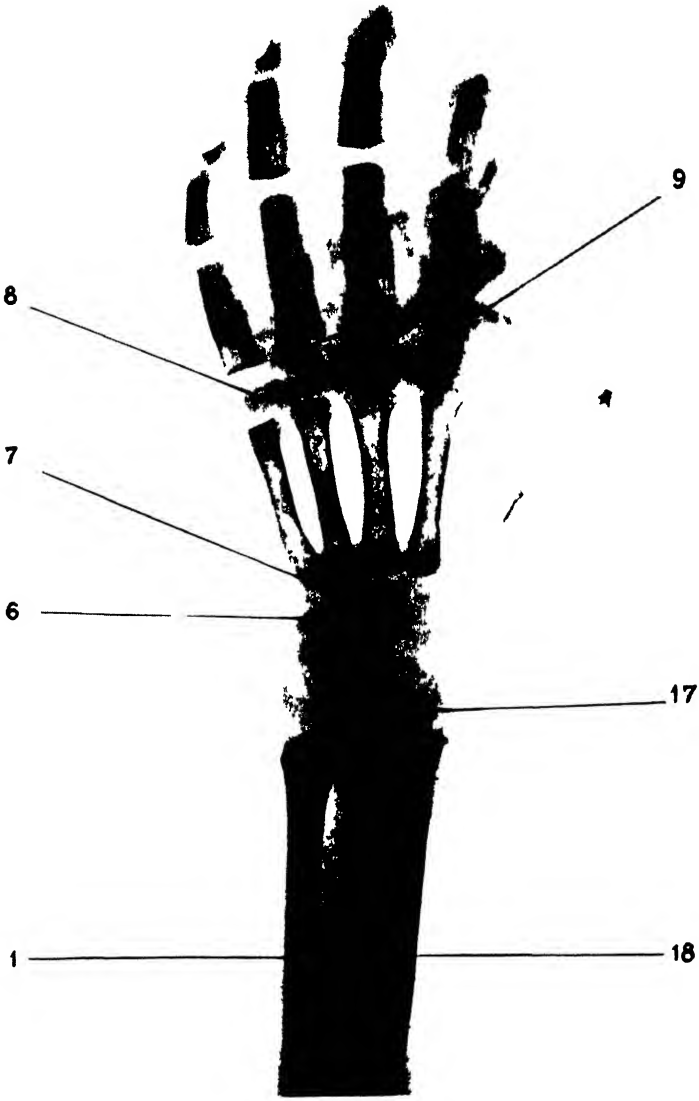

Fig. 57. Left Hand. Dorsal Aspect. 1. Ulna. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2-4 metacarpal bones, the third being the largest. 9. Proximal epiphyses of the first phalanx in 2-4, the third being the largest. 17. Distal epiphyses of radius. 18. Radius.

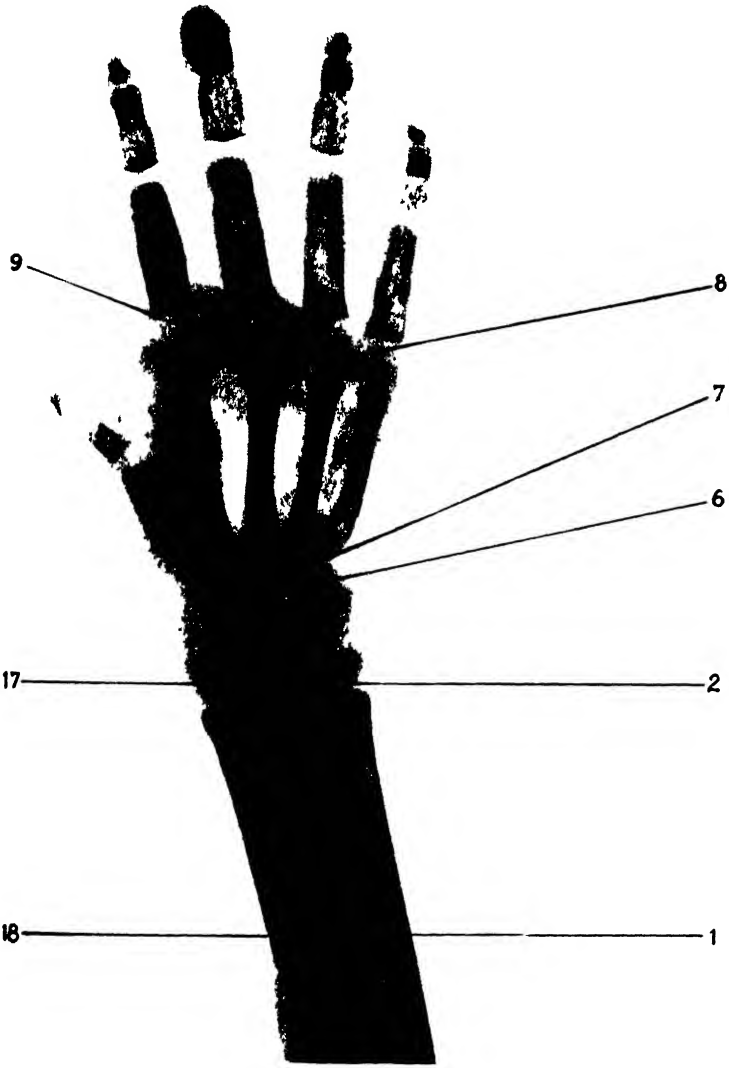

Fig. 58. Right Hand. Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4 metacarpal bones, the third being the largest. 9. Proximal epiphyses of first phalanx in 2, 3, 4, the third being the largest. 17. Distal epiphyses of radius. 18. Radius.

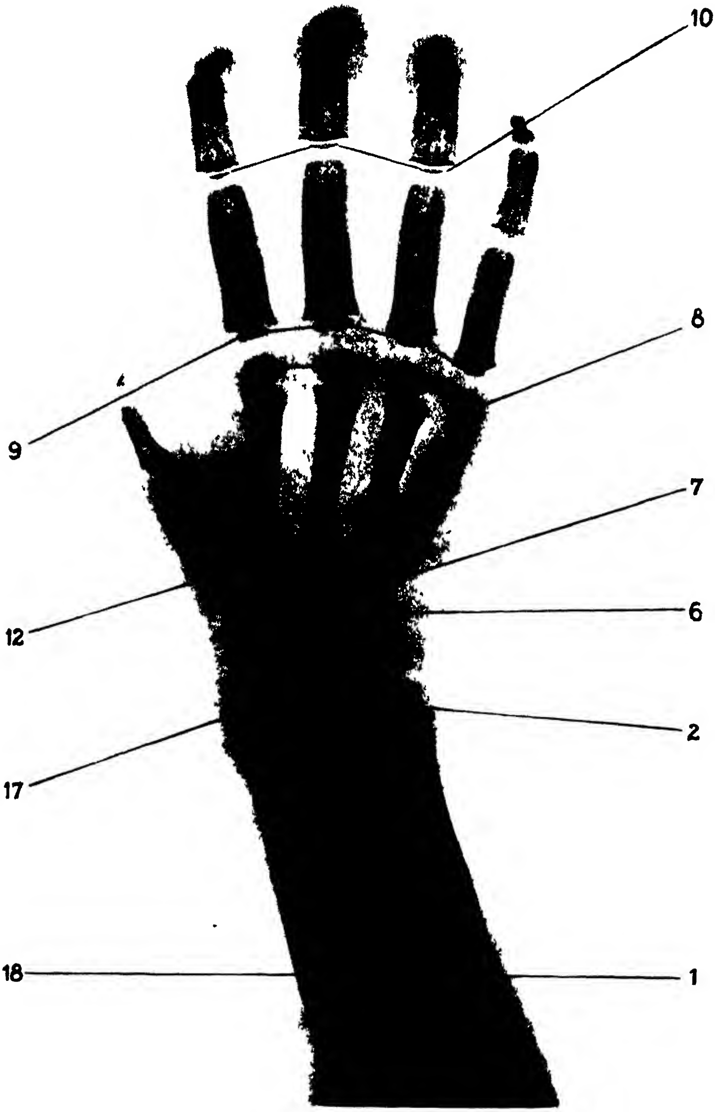

Fig. 59. Left Hand. Volar Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. In this stage the epiphyses are larger and spherical. 9. Proximal epiphyses of first phalanx in 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4. 12. Proximal epiphyses of first metacarpal. 17. Distal epiphyses of radius. 18. Radius.

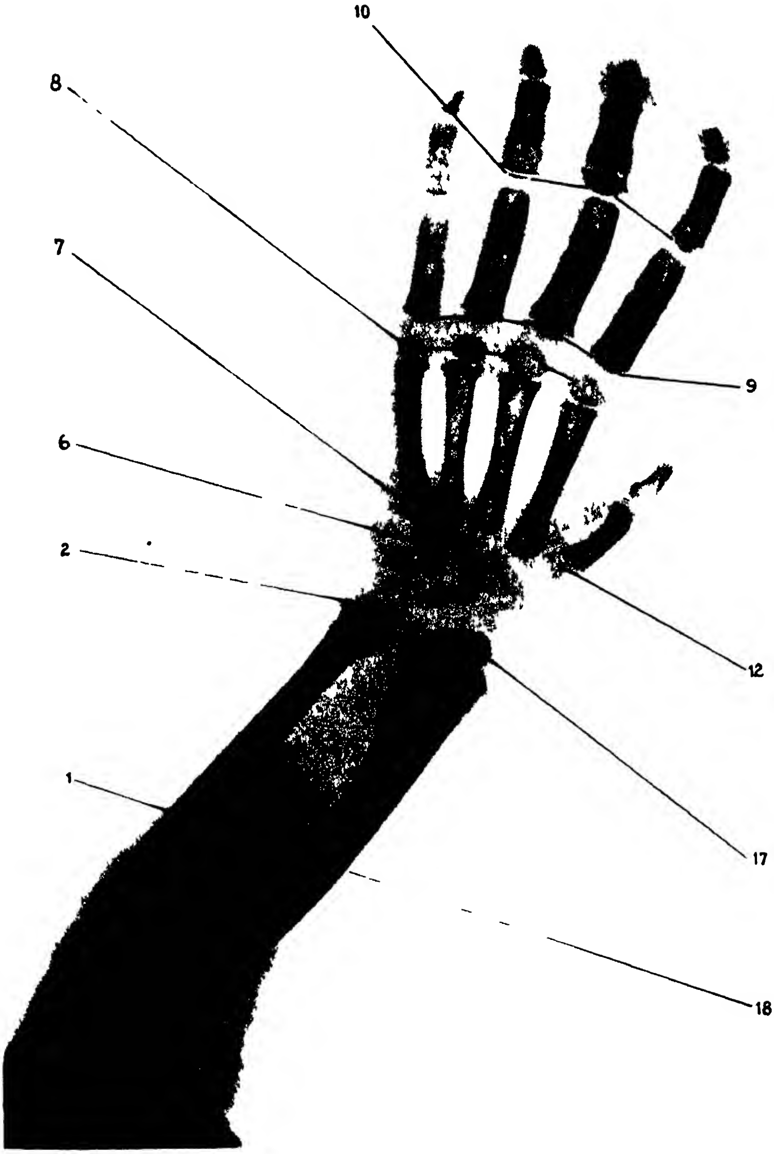

FIG. 60. Right Hand. Volar Aspect. 1 Ulna. 2 Distal epiphyses of ulna. 6 Hamatum. 7 Capitatum. 8 Distal epiphyses 2–5 metacarpal bones. The epiphyses are larger and spherical. 9 Proximal epiphyses of first phalanx 2, 3, 4, 5. 10 Proximal epiphyses of second phalanx 2, 3, 4. 12 Proximal epiphyses of first metacarpal. 17 Distal epiphyses of radius. 18 Radius.

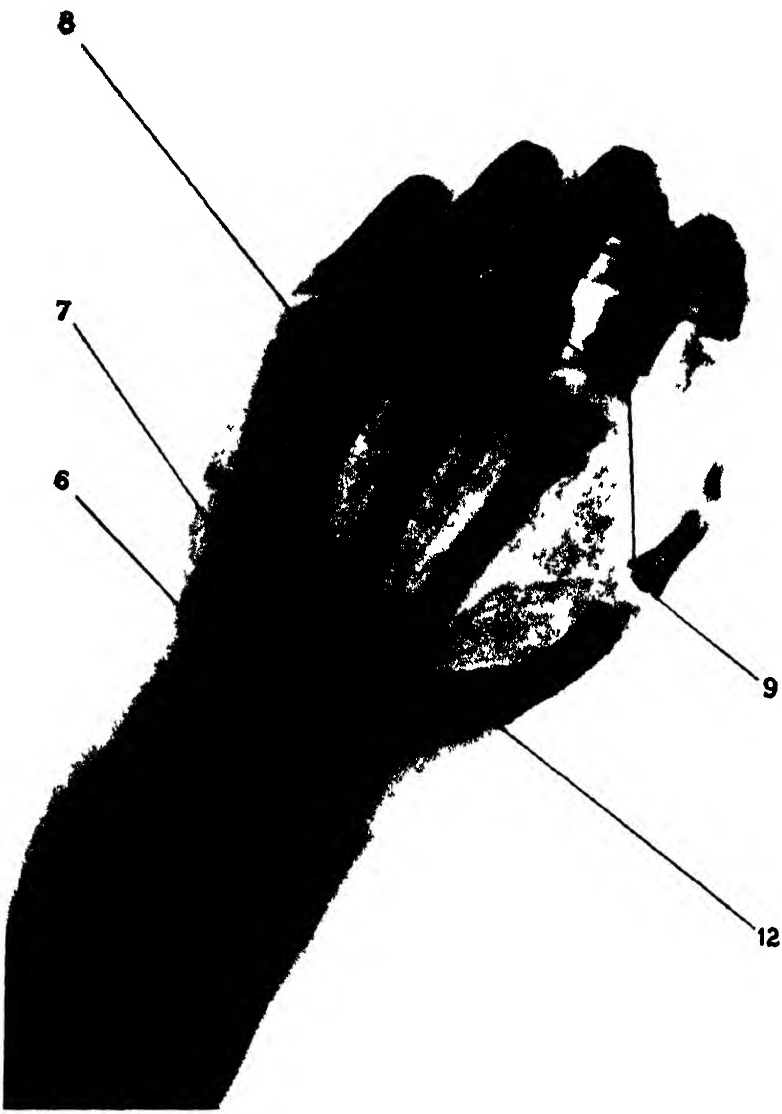

Fig. 61. Left Hand. Dorsal Aspect. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal.

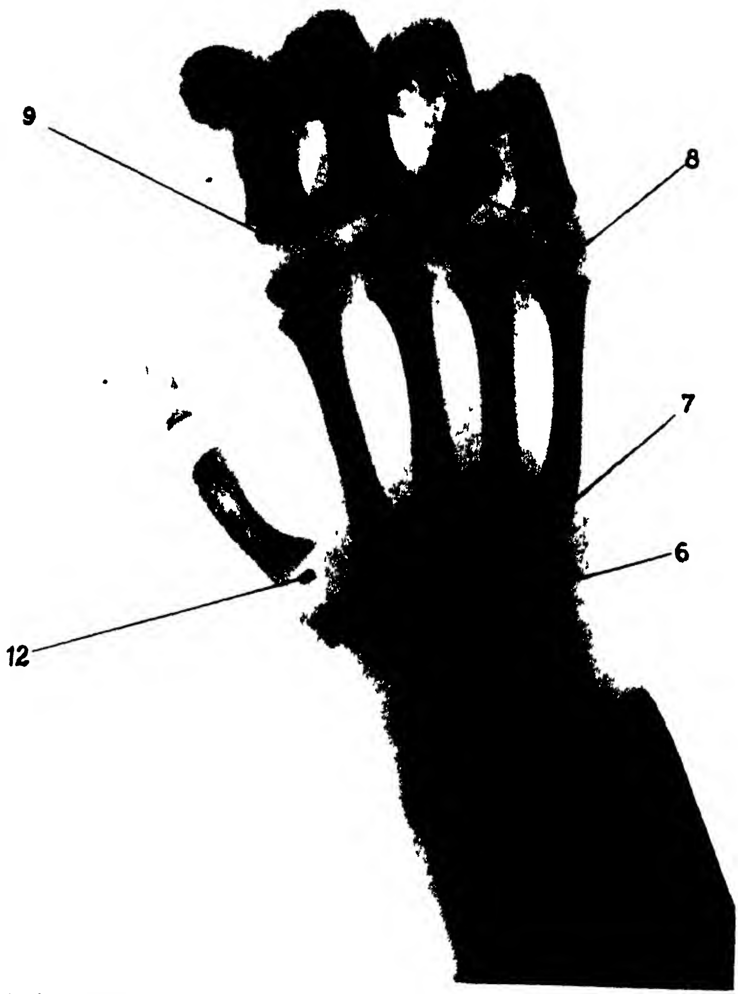

Fig. 62. Right Hand. Dorsal Aspect. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal.

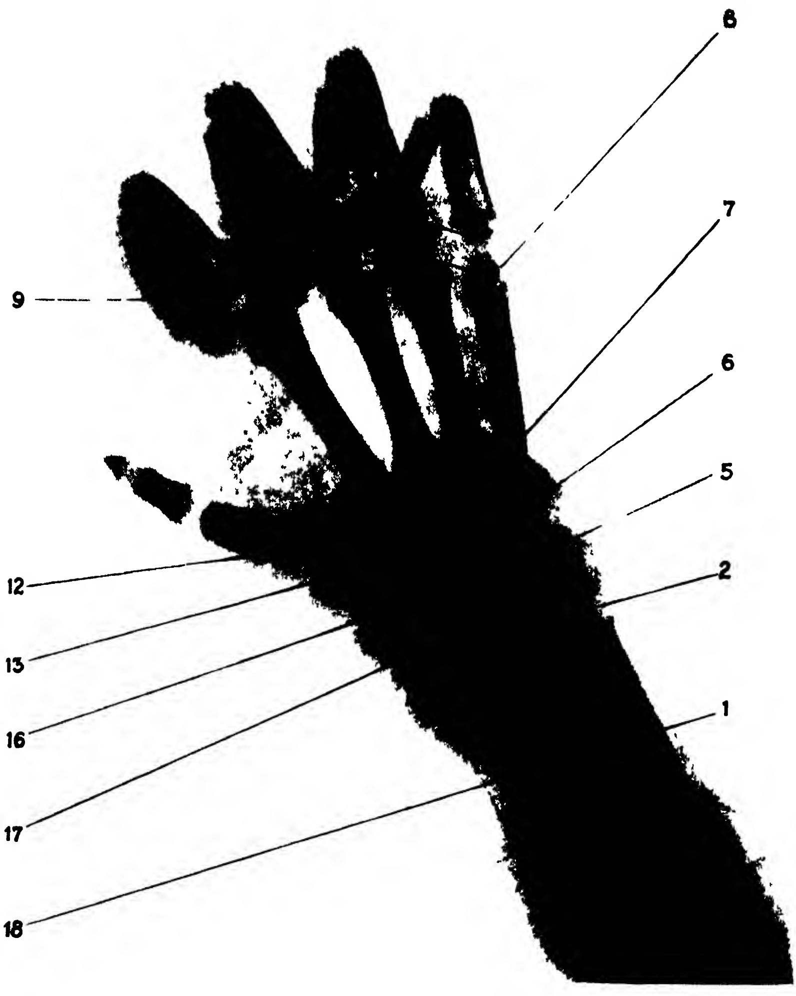

Fig. 63. Right Hand. Dorsal Aspect 1 Ulna 2 Distal epiphyses of ulna 5 Triquetrum 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2 3 4 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 2 3-4-5. 12 Proximal epiphyses of first metacarpal. 13. Multangular major. 16 Navicular. 17. Distal epiphyses of radius 18. Radius.

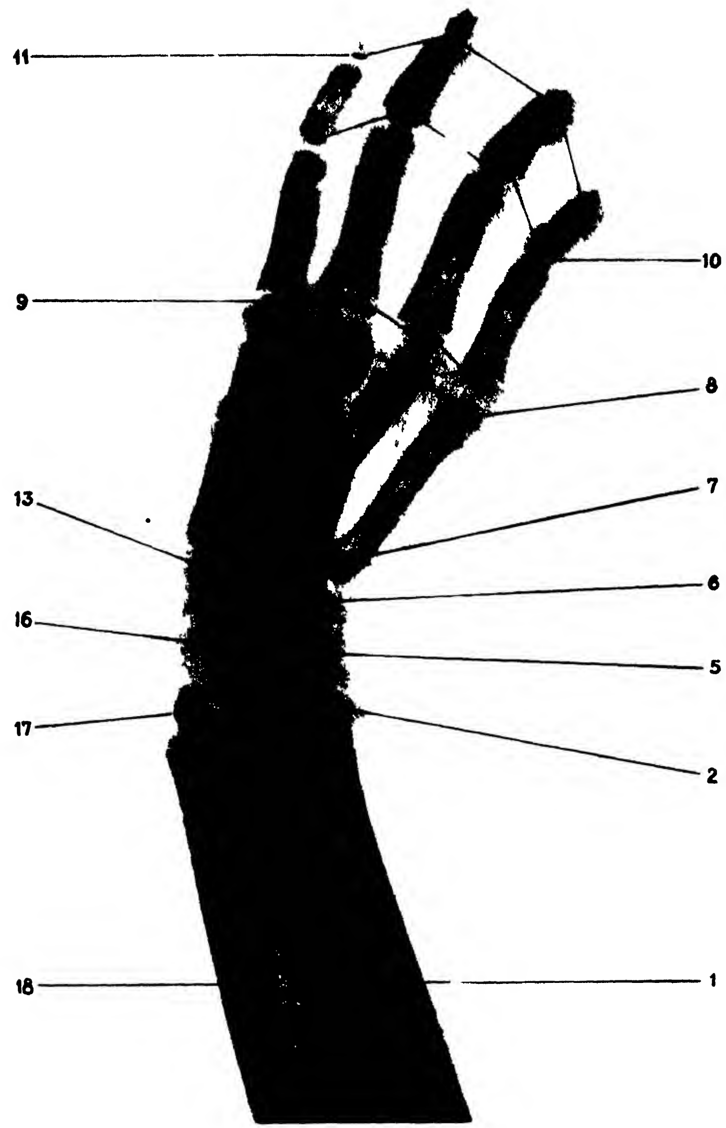

Fig. 64. Right Hand, Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 2, 3, 4, 5. 13. Multangulum major. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

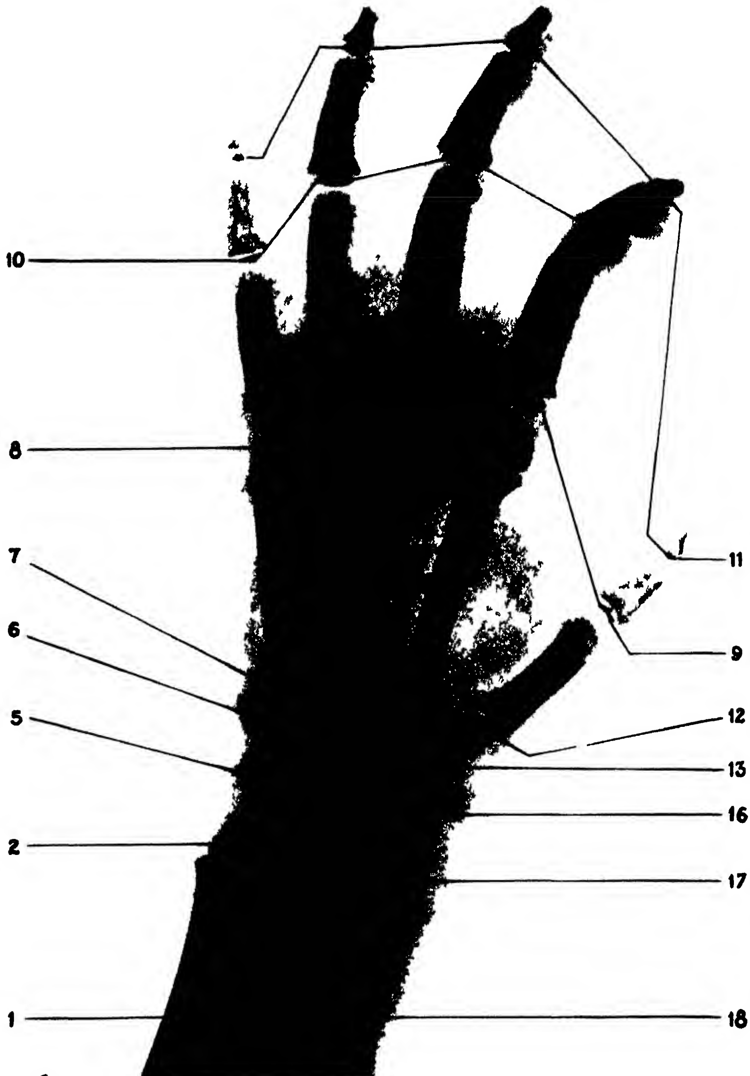

Fig. 57. Left Hand. Dorsal Aspect. 1 Ulna. 2 Distal epiphyses of ulna. 5 Triquetrum. 6 Hamatum. 7 Capitatum. 8 Distal epiphyses 2, 3, 4, 5 metacarpal bones. 9 Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10 Proximal epiphyses of second phalanx 2, 3, 4, 5. 11 Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12 Proximal epiphyses of first metacarpal. 13 Multangulum major. 16 Naviculare. 17 Distal epiphyses of radius. 18 Radius.

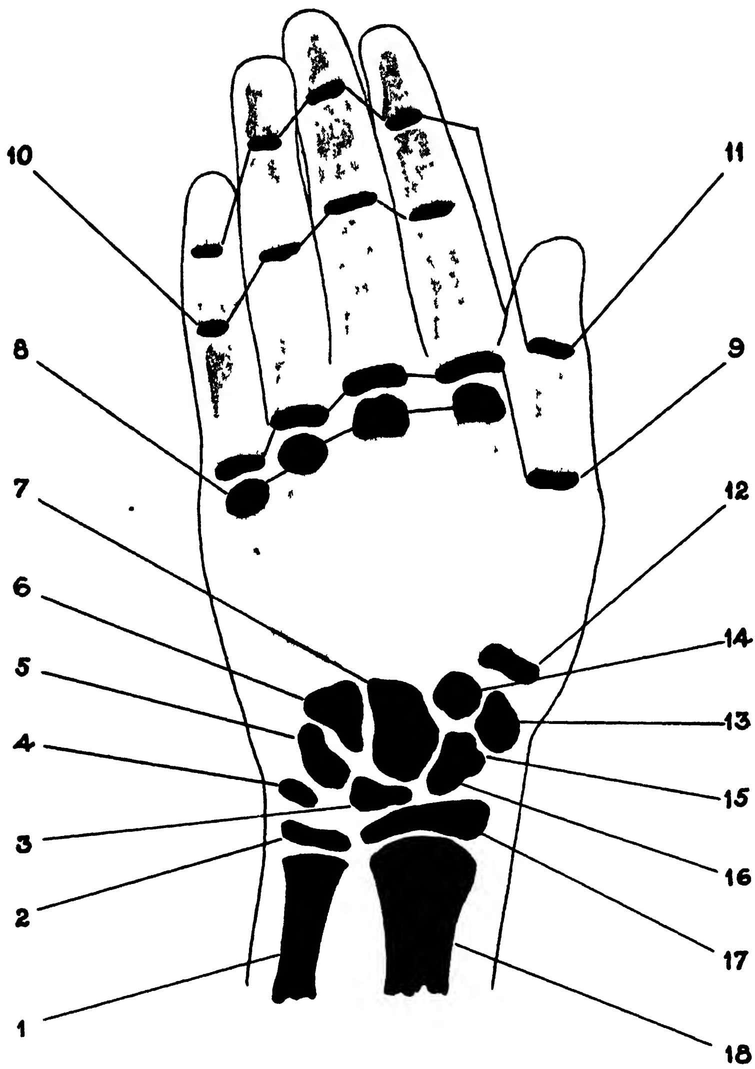

Fig. 66. Outline of Bones of Hand. 1. Ulna. 2. Distal epiphyses of ulna. 3. Lunatum. 4. Pisiform. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal. 13. Multangulum major. 14. Multangulum minor. 15. Centrale. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

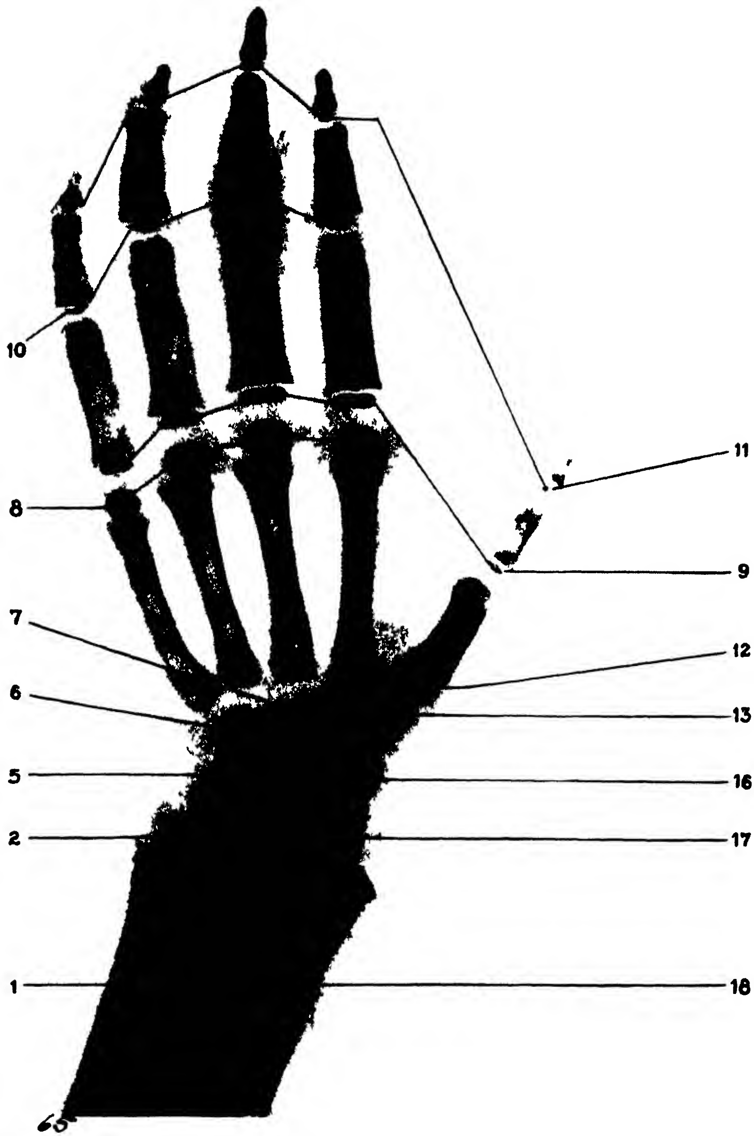

Fig. 65. Left Hand. Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal. 13. Multangular major. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

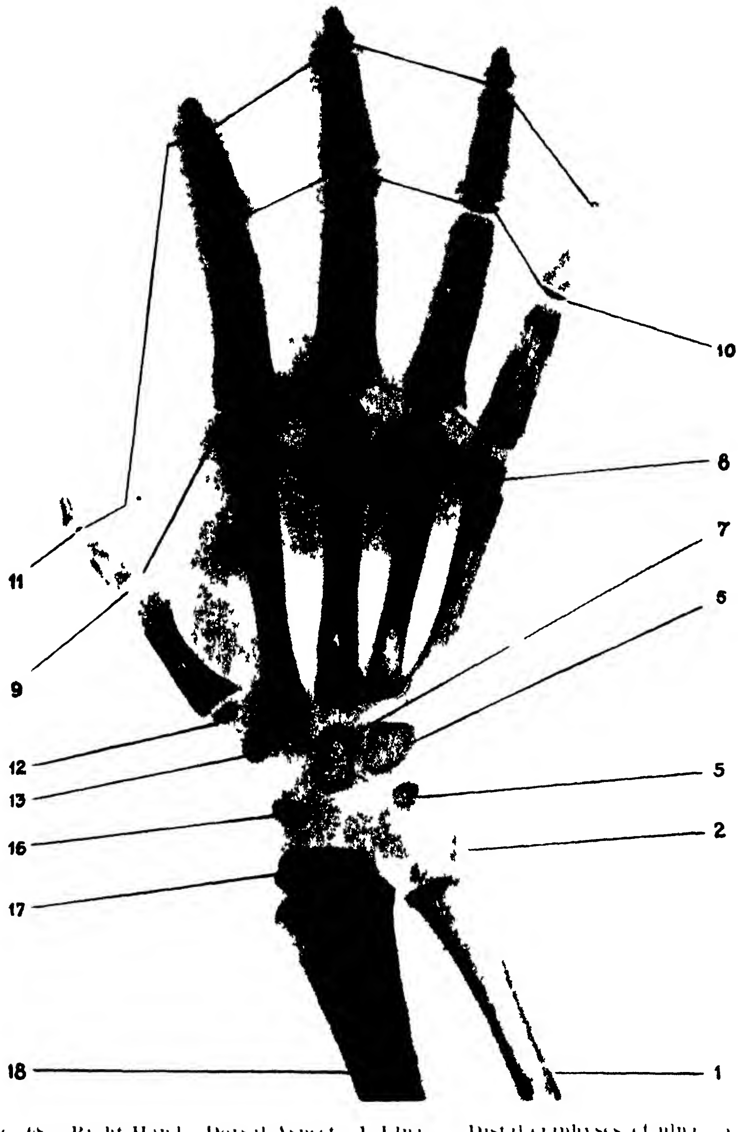

Fig. 68. Right Hand. Dorsal Aspect. 1 Ulna. 2 Distal epiphyses of ulna. 5 Triquetrum. 6 Hamatum. 7 Capitatum. 8 Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9 Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10 Proximal epiphyses of second phalanx 2, 3, 4, 5. 11 Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12 Proximal epiphyses of first metacarpal. 13 Multangulum major. 16 Navicular. 17 Distal epiphyses of radius. 18 Radius.

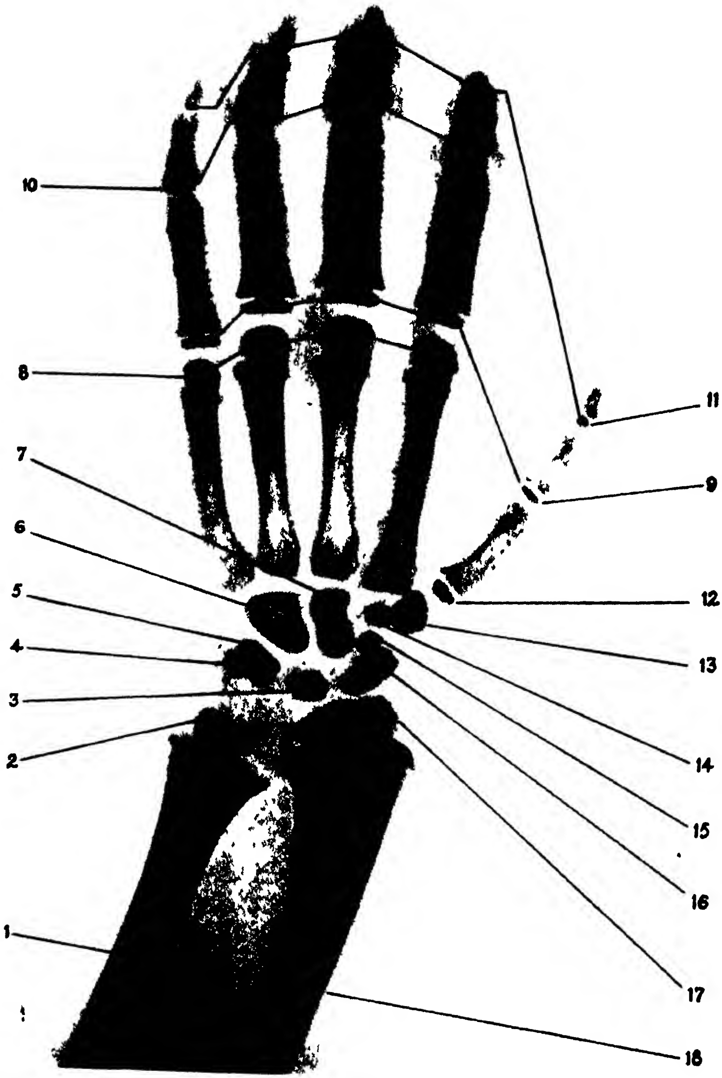

Fig. 69. Left Hand. Dorsal Aspect. 1 Ulna. 2 Distal epiphyses of ulna. 3 Lunatum. 4 Pisiform. 5. Triquetrum. 6 Hamatum. 7 Capitatum. 8 Distal epiphyses of 2 3 4 5 metacarpal bones. 9 Proximal epiphyses of first phalanx 1 2 3 4 5. 10 Proximal epiphyses of second phalanx 2 3 4 5. 11 Proximal epiphyses of third phalanx 1-2-3-4 5. 12 Proximal epiphyses of first metacarpal. 13 Multangular major. 14. Multangular minor. 15 Centrale. 16 Navicular. 17 Distal epiphyses of radius. 18 Radius.

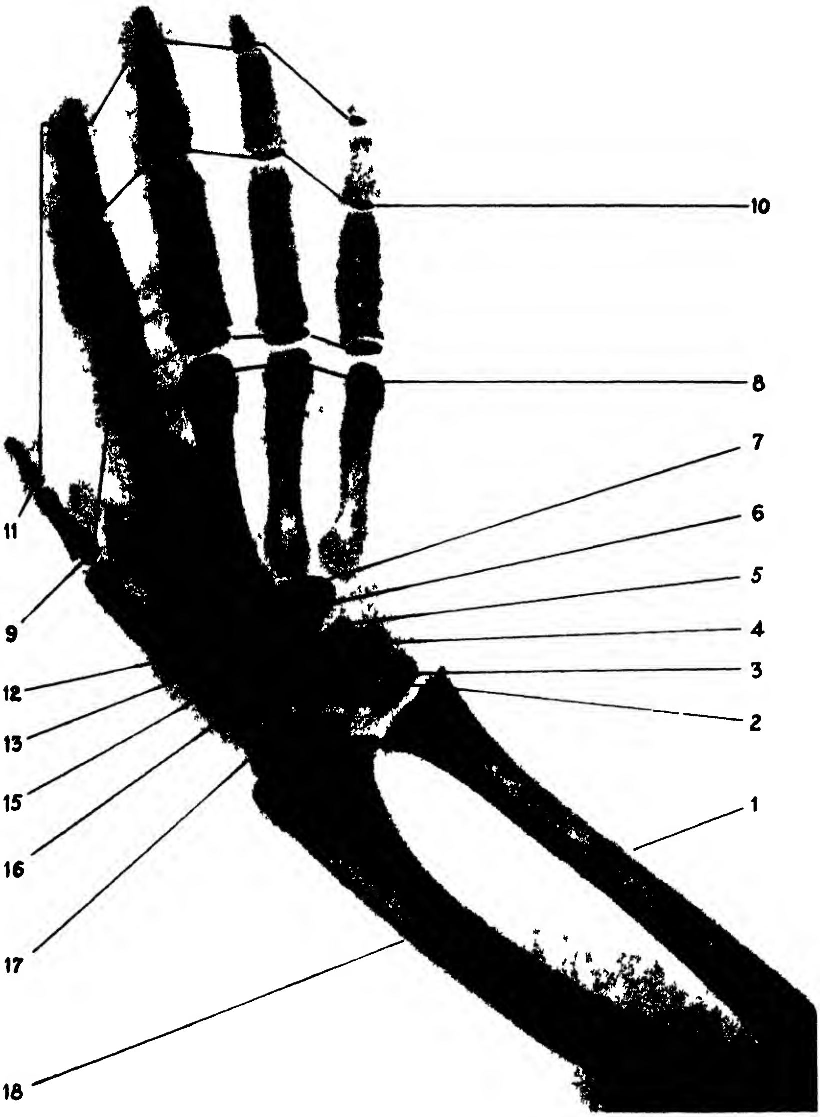

Fig. 70. Right Hand. Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 3. Lunatum. 4. Pisiform. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal. 13. Multangular major. 14. Multangular minor. 15. Centrale. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

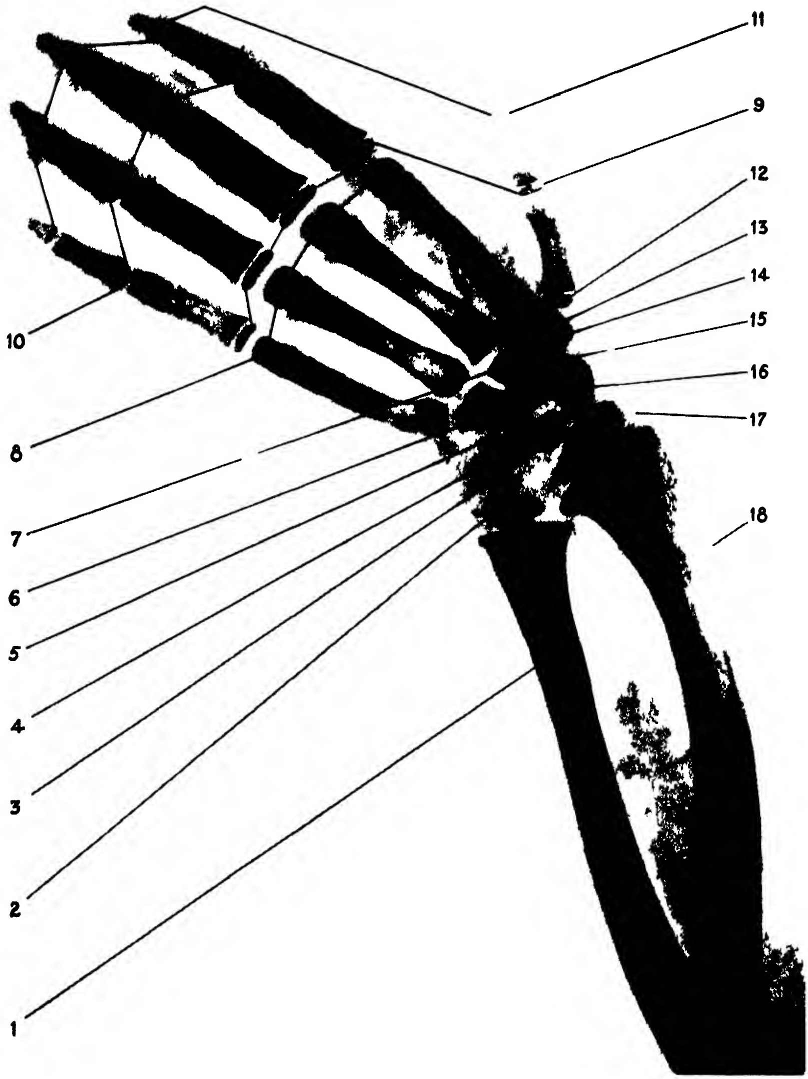

Fig. 71. Left Hand. Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 3. Lunatum. 4. Pisiform. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal. 13. Multangulum majus. 14. Multangulum minus. 15. Centrale. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

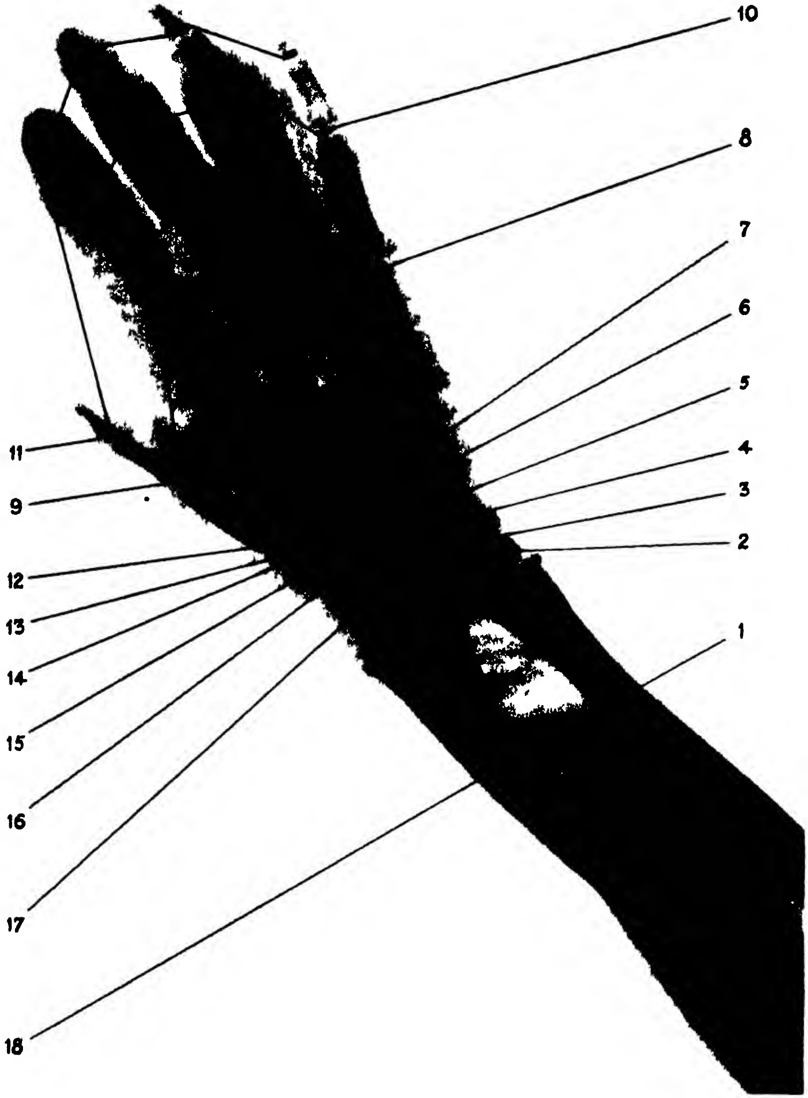

Fig. 72. Right Hand. Dorsal Aspect. 1. Ulna. 2. Distal epiphyses of ulna. 3. Lunatum. 4. Pisiform. 5. Triquetrum. 6. Hamatum. 7. Capitatum. 8. Distal epiphyses of 2, 3, 4, 5 metacarpal bones. 9. Proximal epiphyses of first phalanx 1, 2, 3, 4, 5. 10. Proximal epiphyses of second phalanx 2, 3, 4, 5. 11. Proximal epiphyses of third phalanx 1, 2, 3, 4, 5. 12. Proximal epiphyses of first metacarpal. 13. Multangulum major. 14. Multangulum minor. 15. Centrale. 16. Naviculare. 17. Distal epiphyses of radius. 18. Radius.

DIGITAL EPIPHYSES AND CARPAL BONES IN THE GROWING INFANT FEM

Charles V. Noba

	Estimated Age in Months	Sitting Height in Centimeters	Weight in Kilograms	Dentition	Radius	Ulna	Dist Epiphy Radi
Stage 1 Specimen 1 C A 1105 Figs 57 and 58	9 to 12	37 5	3 56	8 incisors 4 premolars Total 12	Slight Bowing	Relatively Straight	Right Left Vis
Stage 2 Specimen 2, Trixie Figs 59 and 60	14 to 16	41 0	4 66	8 incisors 4 canines 4 1st premolars 4 2nd premolars milk dentition in process of completion See Note 1 Total 20	Slight Bowing	Relatively Straight	Right a Left Vis
Stage 3 Specimen 3 McGregor Figs 61 and 62	16 to 18	43 5	2	8 incisors 4 canines 4 1st premolars 4 2nd premolars Total 20	No Record	No Record	Negat Not cl
11/3/28 Stage 4 Specimen 5 Penserosa Figs 63 and 64	18 to 20	See Foot note No 2 No record	7 54	8 incisors 4 canines (Note 3) 4 1st premolars 4 2nd premolars Total 20	No Record	Radiograph of No Record	right hand Right Visible
3/10/29 State 5 Specimen 5 Penserosa Fig 65	24 to 26	47 5	11 10	8 incisors 4 canines 4 1st premolars 4 2nd premolars Total 20	No Record	Radiograph of No Record	left hand Right a Left Vi
Stage 6 Specimen 4 C A 1216 Figs 67 and 68	24 to 30	53 0	Emaciated 10 9	Full set of milk teeth canines large Total 20	No Record	No Record	Right a Left Vis
3/2/30 Stage 7 Specimen 5 Penserosa Figs 69 and 70	34 to 38	54 5	19 43	The four first permanent molars erupted during February and March 1930 Milk Teeth 20 Permanent Molars 4 Total 24	Bowed	Relatively Straight	Right a Left Vis
7/25/30 Stage 8 Specimen 5 Penserosa Figs 71 and 72	40 to 42	63 5	24 00	Milk Teeth 20 Permanent Molars 4 Total 24	Bowed	Relatively Straight	Right a Left Visib

1 The upper right canine tooth has just erupted—breakin erupted—its tip is breaking through the gums Both (ri Both upper second premolar teeth (right and left) cutting

2

Date	Length Crown-Heel
May 18 1929	72 centimeters
Mch 3 1930	86
Sept 3 1930	no record

3 The canine teeth are not much higher than the incisor

ORILLA, WITH SITTING HEIGHT, WEIGHT DENTITION AND ESTIMATED AGE
w York Zoological Park

Distal Epiphyses Ulna	Carpal Bones in Probable Order of Appearance	Proximal Epiphyses First Metacarpal	Distal Epiphyses 2-3-4-5 Metacarpals	Proximal Epiphyses First Phalanx 1 2 3 4 5	Proximal Epiphyses Second Phalanx 2 3 4 5	Proximal Epiphyses Third Phalanx 1 2 3-4 5
Only Right Visible	Capitatum (Magnum) Hamatum (Unciform) Total 2	None Visible 0	Spherical and porous 2 3 4 Visible 3	Ovoid discs 2 3-4 Visible 3	None Visible 0	None Visible 0
Right and Left Visible Left Larger	Capitatum (Magnum) Hamatum (Unciform) Total 2	Both visible One in each hand 1	Spherical and porous 2 3 4 5 Visible 4	Ovoid webbed discs in 2 3 4 The 5th is spherical and webbed Visible 4	Ovoid webbed discs 2 3 4 Visible 3	None Visible 0
Negative Not clear	Capitatum (Magnum) Hamatum (Unciform) Total 2	Both visible One in each hand 1	Spherical and webbed 2 3 4 5 Visible 4	Ovoid webbed discs 2 3 4 Visible 4	Ovoid webbed discs 2 3 4 5 Visible 4	Contracted hand renders Negative poor
age 4 Right Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Navicular (Scaphoid) Multangular major (Trapezium) Total 5	Right Visible 1	Spherical and webbed 2 3 4 Visible 4	Ovoid webbed discs 2 3 4 Visible 4		Ovoid webbed discs 2 3-4 5 Visible 4
age Right and Left Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Navicular (Scaphoid) Multangular major (Trapezium) Total 5	Both Visible Right and Left 1	Spherical and webbed 2 3 4 5 Visible 4	Ovoid webbed discs 1 2 3 4 Visible 5	Ovoid webbed discs 2 3 4 5 Visible 4	Ovoid webbed discs 2 3 4 5 Visible 4
Right and Left Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Navicular (Scaphoid) Multangular major (Trapezium) Total 5	Both Visible Right and Left 1	Spherical and webbed 4 5 Visible 4	Ovoid webbed discs 1 2 3 4 5 Visible 5	Ovoid webbed discs 2 3 4 5 Visible 4	Ovoid webbed discs 1 2 3 4 5 Visible 5
Right and Left Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Navicular (Scaphoid) Multangular major (Trapezium) Multangular minor (Trapezoid) Lunatum (Lunar) Pisiforme (Pisiform) Centralia (Centrale) Total 9	Both Visible Right and Left 1	Spherical and webbed [illegible] 4 Visible 4	Ovoid webbed discs 1 2 3 4 5 Visible 5	Ovoid webbed discs 2 3 4 5 Visible 4	Ovoid webbed discs 1-2 3 4 5 Visible 5
Right and Left Visible	Same on fusion of centralia and navicular Total 9	Both Visible Right and Left 1	Spherical and webbed 2 3 4 5 Fusion in right hand Visible 4	Ovoid webbed discs 1-2-3-4-5 Visible 5	Ovoid webbed discs 2 3-4 5 Visible 4	Ovoid webbed discs 1 2 3-4-5 Fusion in second Visible 5

OTES

ough the gums The upper left canine tooth has not quite
nd left) lower canine teeth are just coming through the gums
ugh the gums All the lower premolar teeth (4) have erupted

Sitting Height Crown-Rump	Span (Lying on Back Arms Outstretched)
47.5 centimeters	106 centimeters
54.5	122
63.5 "	130 "

...LLA, WITH SITTING HEIGHT, WEIGHT, DENTITION AND ESTIMATED AGE
...k Zoological Park

...istal ...physes ...lna	Carpal Bones in Probable Order of Appearance	Proximal Epiphyses First Metacarpal	Distal Epiphyses 2 3 4 5 Metacarpals	Proximal Epiphyses First Phalanx 1 2 [illegible] 4	Proximal Epiphyses Second Phalanx 2 3 4 5	Proximal Epiphyses Third Phalanx 1 2 3 4 5
Right visible	Capitatum (Magnum) Hamatum (Unciform) Total 2	None Visible 0	Spherical and prisms 2 [illegible] 4 Visible	Ovoid discs 2 3 4 Visible 3	None Visible 0	None Visible 0
...ht and ... Visible ... Longer	Capitatum (Magnum) Hamatum (Unciform) Total 2	Both visible One in each Hand 1	Spherical and prisms 2 [illegible] 4 5 Visible 4	Ovoid webbed discs in 2 [illegible] 4 The others spherical and webbed Visible [illegible] 4	Ovoid webbed discs 2 3 4 Visible 3	None Visible 0
...gative [illegible]	Capitatum (Magnum) Hamatum (Unciform) Total 2	Both visible One in each Hand 1	Spherical and webbed 2 [illegible] 4 5 Visible 4	Ovoid webbed discs 2 [illegible] 4 Visible 4	Ovoid webbed discs 1 [illegible] 2 3 4 5 Visible 4	Contracted hand renders Negative poor
4 Right visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Naviculare (Scaphoid) Multangulum majus or Trapezium Total 5	Right Visible 1	Spherical and webbed 2 [illegible] 4 Visible 4	Ovoid webbed discs 2 [illegible] 4 Visible 4		Ovoid webbed discs 2 3 4 5 Visible 4
...ght and ...t Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Naviculare (Scaphoid) Multangulum majus (Trapezium) Total 5	Both Visible Right and Left 1	Spherical webbed 1 Visible 4	Ovoid webbed discs 1 2 3 4 Visible	Ovoid webbed discs 2 3 4 Visible 4	Ovoid webbed discs 2 [illegible] 4 Visible 4
...ght and ...t Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Naviculare (Scaphoid) Multangulum majus (Trapezium) Total 5	Both Visible Right and Left 1	Spherical and webbed 2 [illegible] 4 Visible 4	Ovoid webbed discs 1 2 3 4 Visible	Ovoid webbed discs 2 3 4 Visible 4	Ovoid webbed discs 1 2 [illegible] 4 5 Visible
...ight and ...ft Visible	Capitatum (Magnum) Hamatum (Unciform) Triquetrum (Cuneiform) Naviculare (Scaphoid) Multangulum majus (Trapezium) Multangulum minus (Trapezoid) Lunatum (Lunar) Pisiforme (Pisiform) Centrale (Centrale) Total 9	Both Visible Right and Left 1	Spherical and webbed 2 [illegible] 4 Visible 4	Ovoid webbed discs 1 2 [illegible] 4 Visible 5	Ovoid webbed discs 2 [illegible] Visible 4	Ovoid webbed discs 1 2 3-4 5 Visible 5
...ight and ...ft Visible	Since ... fusion of centrale and naviculare Total 9	Both Visible Right and Left 1	Spherical and webbed 2 3 4 5 Fusion in right hand Visible 4	Ovoid webbed discs 1-2-3-4-5 Visible 5	Ovoid webbed discs 2 3-4 5 Visible 4	Ovoid webbed discs 1 2 3-4 5 Fusion in second Visible 5

...rs

...gh the gums The upper left canine tooth has not quite ...left) lower canine teeth are just coming through the gums ...h the gums All the lower premolar teeth (4) have erupted

Sitting Height Crown Rump	Span (Lying on Back Arms Outstretched)
47 5 centimeters	106 centimeters
54 5	122
63 5 "	130 "

THE GREAT SMOKY MOUNTAINS
WITH PRELIMINARY NOTES ON THE SALAMANDERS OF MT. LECONTE AND LECONTE CREEK

By GERVASE W. MCCLURE, M.A.
Research Fellow
New York Zoological Society
New York University

(Figs. 73-82 incl.)

OUTLINE

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Location — Physiography, Geology, Streams, Coves.
Flora — Trees, Shrubs and Plants, Ferns, Liverworts, and Mosses.
Fauna — Animal Life.
Summary.

IV. DESCRIPTION OF LECONTE CREEK.
Chestnut Zone—Transitional Zone—Birch Zone—Balsam Zone—Summary.

V. THE PROBLEM.

VI. TECHNIQUE AND METHODS.

VII. DISCUSSION — Salamander Species.
Desmognathus quadra-maculata
Desmognathus phoca
Desmognathus fuscus carolinensis
Plethodon jordani
Cyrinophilus danielsi
Eurycia bislineata wilderae
Larvae

VIII. SUMMARY.

I. Introduction.

During the year 1928-29, the writer submitted a thesis entitled, "An Ecological Study of the Distribution of Animals on Mt. LeConte, and along LeConte Creek," to the Graduate Committee of the University of Tennessee in partial fulfillment of the requirements for the degree of Master of Arts. The thesis was the result of a study of the Great Smoky Mountains and a preliminary ecological survey of the distribution of its fauna, based on observations and collections. The collection is composed of a large number of snails, crayfishes, spiders, insects, salamanders, toads, lizards, snakes, and others. From this collection the identification of the salamanders has been made, and it was thought advisable to publish a brief description of the Smoky Mountains, together with the notes on salamanders.

II. Acknowledgments.

The writer wishes to express his gratitude to Dr. E. B. Powers, Department of Zoology, University of Tennessee, who has offered many helpful suggestions throughout the year; and to Dr. G. K. Noble, and associates, Department of Herpetology, American Museum of Natural History, New York City, who identified the various specimens of the collection.

Thanks are due to Mr. James E. Thompson, Knoxville, Tennessee, who furnished photographs illustrating the various habitats.

Grateful acknowledgments are due the New York Zoological Society for the publication; and Dr. Horace W. Stunkard, New York University, for assisting in the preparation of the manuscript.

III. The Great Smoky Mountains.

Location.

The term Smoky Mountains is somewhat synonymous with the Unaka Mountains which continue westward along the entire border line between Tennessee and North Carolina to Georgia. But that part of this range bounded by the Pigeon River which breaks through from North Carolina on the northwest, and the

Little Tennessee River on the southwest can be called the Great Smoky Mountains proper.

Physiography.

The entire length of the Smoky Mountains, which is approximately sixty miles, for the most part, forms the water divide between Tennessee and North Carolina. The width of the mountains varies extensively, but is approximately thirty miles. The acreage has been estimated to be more than 450,000. The altitude varies from 1,500 to over 6,600 feet above sea level, forming the steepest vegetative slopes in America. The temperature varies from 100 degrees F. at the base in the hot summer days to 20 degrees F. below zero on the summit in the coldest winter nights.

Geology.

Geologically the Great Smoky Mountains are the oldest mountains in America. They are composed of limestones, shales, slates, sandstones, quartzites, conglomerates, gneisses, schists, and perhaps granite. They range from the Mississippian to the Archean period, and most of them are Pre-Cambrian. They are apparently non-fossiliferous. So far as is known there are no mineral or ore deposits of economic importance found in this locality.

Peaks.

For more than twenty-eight miles, the crest of the mountain rises more than a mile above sea level. Among the most important peaks are Mount Cuyot, Clingman's Dome, Siler's Bald, Thunderhead, Laurel Top, Mount Collins, Briar Knob, and many others. But the most outstanding is Mount LeConte.

Streams.

The region as a whole is mesophytic. Scarcely does a day pass that there is not a drenching rainfall in some section. Hence there are numerous streams throughout the whole mountain region. Among the largest, as known by the natives, are Little Tennessee, Little River, Little Pigeon, and Pigeon, with their tributaries.

Coves.

There are numbers of rich coves at the base of the mountains that are inhabited by Anglo-Saxon stock. Among these are Jones Cove, Emerts Cove, Wears Cove (Valley), Tuckaleechee Cove, Cades Cove, Cosby Cove, and many others.

Trees.

The forest as a whole may be classed as deciduous, although coniferous trees dominate the summits of the higher peaks and may be found throughout the slopes. The hard woods include many species, chief of which are poplar, basswood, white oak, black oak, chestnut, sugar maple, buckeye, birch, and beech. The soft woods consist of white pine, shortleaf yellow pine, hemlock, spruce, balsam, Virginia scrub pine, and pitch pine.

Shrubs and Plants.

Among the trees along the slopes are found mountain laurel (ivy), rhododendron, sand myrtle, dogwood, redbud, vacinium, dog hobble, flame azalea, trilliums, orchids, trailing arbutus, Virginia bluebells, sorrel, violets of many species, and over two hundred varieties of flowering shrubs and plants varying from semi-tropical to those of the Canadian region.

Ferns, Liverworts, and Mosses.

There is a great number of ferns, liverworts, and mosses throughout the entire section. In many places the ground and ledges are completely covered, especially at the higher altitudes, where large beds of sphagnum and mountain fern-moss form a carpet more than a foot deep.

Animal Life.

To the average person, animal life may appear comparatively scarce. Yet a naturalist may find an abundance of wild life in the various habitats. Among the lower levels, occur animals that are common in East Tennessee. A large variety of snails, spiders, centipeds, including scorpions, are typical. Of the insects most of the orders are represented by one or more species. Spring-tails (Collembola) are abundant on the moist ground

everywhere. Grasshoppers, crickets, katy-dids, and cockroaches are abundant on the forest margin and lower slopes. May-flies and stone-flies are found near the water, and the nymphs are abundant in the swift streams. A few dragon-flies may also be found. There is a large number of hemipterous insects found both in the water and on the flora. Of the beetles, ground and wood-boring species are more prominent. Scorpion-flies may be noted in the thick field strata along the trails. In the streams numerous caddice-fly nymphs may be found. Butterflies and hymenopterous insects are found wherever there are flowers at any level.

In many of the streams and brooks there can be found bass, perch, rainbow, and speckled trout. Many other species of fish, common in East Tennessee, may be found in the lower altitudes.

The most abundant of all amphibia are the salamanders. They abound in the streams and moist slopes, and may be collected in any locality. Toads are abundant, while frogs are found in the low altitudes.

Several species of lizards are found along the forest margin. There are also a few land and fresh water turtles.

A few varieties of snakes are found. The two most dreaded are the rattler and copperhead, these being the only two known to possess poisonous fangs. The black snake, blue-racer, fox snake, water snake, garter snake, king snake, and the small ring necked snake are present, but are not often encountered.

The summer-dwelling birds number less than one hundred species. Among the most common, dwelling near the settlements and along the mountain sides, are sparrows, bobwhites, doves, woodpeckers, flickers, goldfinches, towhees, cardinals, indigo buntings, yellow-breasted chats, wood thrushes, brown thrashers, wrens, robins, and various warblers. Those that choose the higher altitudes are the ruffed grouse, wild turkey, yellow-bellied sapsucker, Canada warbler, Wilson thrush, brown creeper, pheasant, golden eagle, northern raven, and the duck hawk. Chimney swifts, chickadees, and the Carolina juncos are most abundant.

Many of the mammals that once roamed the forest have become extinct. Others have become so scarce that weeks are re-

quired to locate them. Among the animals that are left in the Smokies are the Virginia oppossum, Virginia deer, wood hare, Carolina wood vole (mouse), woodchuck, eastern chipmunk, red squirrel, raccoon, Carolina weasel, Carolina skunk, American black bear, gray fox, red fox, wild cat, shrew, and bats.

Summary.

The Great Smoky Mountain section of North Carolina and Tennessee is noted for its ruggedness of area, its variation of altitude and temperature, its geological age, its humid atmosphere, its unparalleled variety of trees, flowering shrubs and plants, and its innumerable host of animal life. These have attracted scientists and nature-loving tourists from every part of the United States, and from many parts of the world.

The great demand for the preservation of this virgin forest, has inspired public spirited citizens to purchase the holdings of private lumber companies and soon this section will become "The Great Smoky Mountain National Park".

IV. Description of LeConte Creek

A close observation of the valley has been made and it has been zoned according to the vegetation, which is composed of virgin timber. Each zone was divided into plots, one thousand feet in length.

Chestnut Zone.

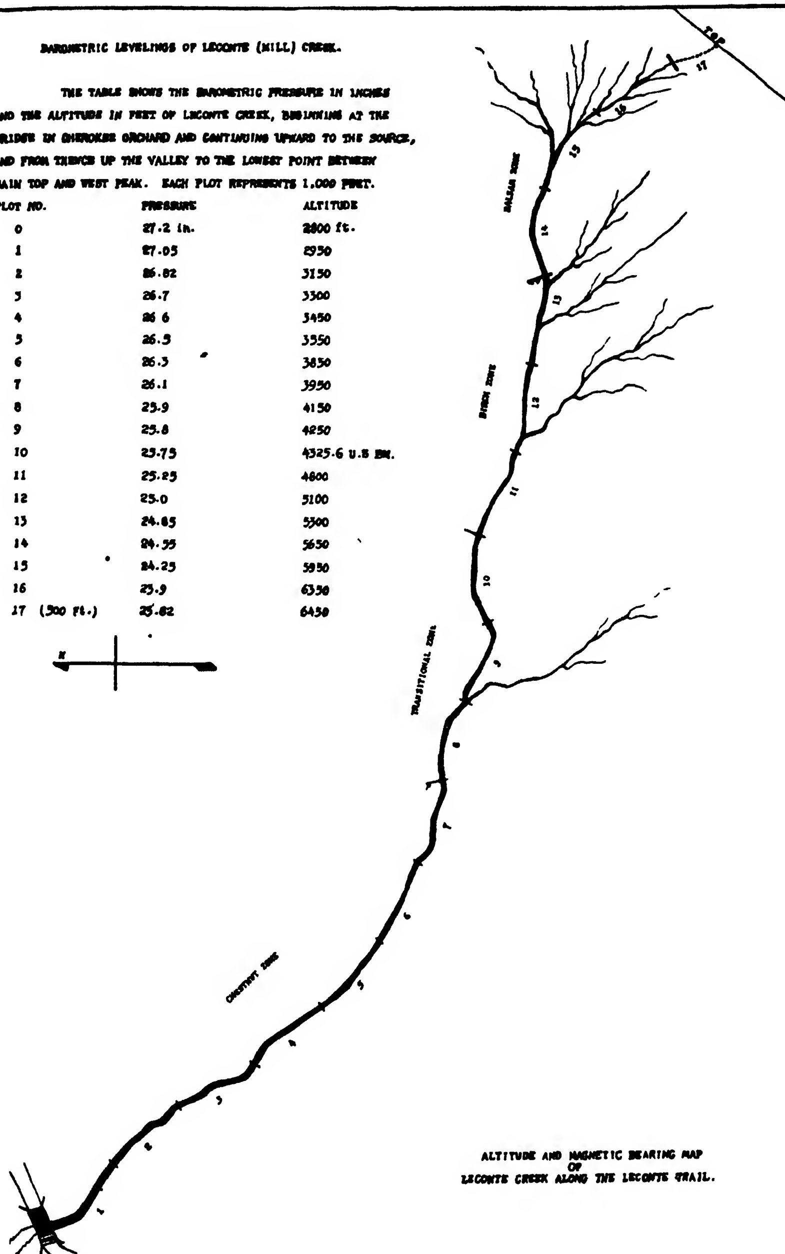
The first zone extends approximately one and one-half miles, and includes the first seven plots. It is largely composed of oaks, birches, buckeyes, poplars, and beeches, which attain a very large size. But the dominant tree is the chestnut; this is being destroyed by the chestnut blight and apparently is being replaced by oaks. Numerous shrubs and plants are present. A number of large trees have fallen and are in a decaying state.

The stream in this zone has an average of about 10 percent fall and is for the most part shallow, containing numerous large boulders, some of which are covered with moss and rock ferns. Several deep pools are formed where the water plunges over large rocks. Two or three small islands are formed at the bases of the coves; these contain trees and other vegetation.

BAROMETRIC LEVELINGS OF LECONTE (MILL) CREEK.

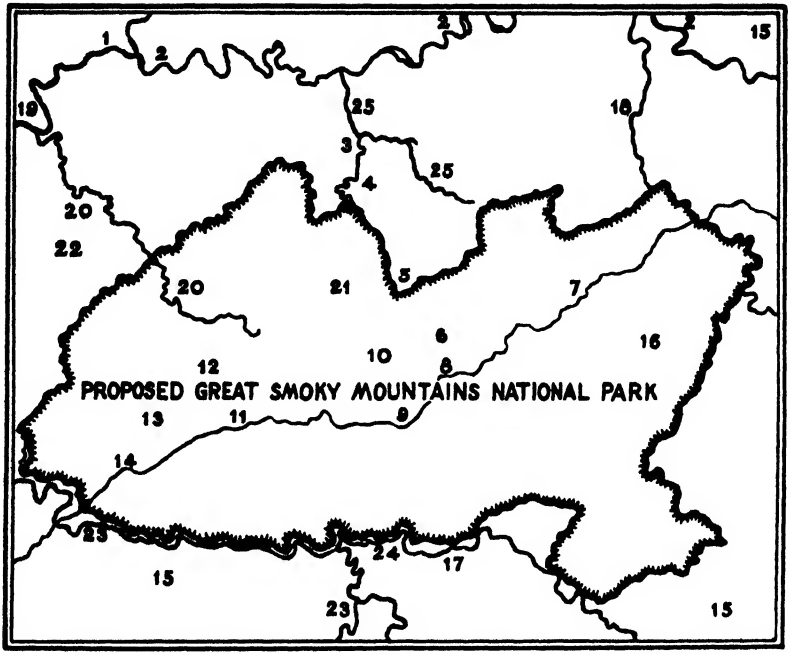
THE TABLE SHOWS THE BAROMETRIC PRESSURE IN INCHES AND THE ALTITUDE IN FEET OF LECONTE CREEK, BEGINNING AT THE BRIDGE IN CHEROKEE ORCHARD AND CONTINUING UPWARD TO THE SOURCE, AND FROM THENCE UP THE VALLEY TO THE LOWEST POINT BETWEEN MAIN TOP AND WEST PEAK. EACH PLOT REPRESENTS 1,000 FEET.

PLOT NO.	PRESSURE	ALTITUDE
0	27.2 in.	2800 ft.
1	27.05	2950
2	26.82	3150
3	26.7	3300
4	26 6	3450
5	26.5	3550
6	26.3	3850
7	26.1	3950
8	25.9	4150
9	25.8	4250
10	25.75	4325.6 U.S BM.
11	25.25	4800
12	25.0	5100
13	24.85	5300
14	24.55	5650
15	24.25	5950
16	23.9	6350
17 (300 ft.)	23.82	6450



ALTITUDE AND MAGNETIC BEARING MAP OF LECONTE CREEK ALONG THE LECONTE TRAIL.

Figure 74.



OUTLINE MAP OF SMOKY MOUNTAINS NATIONAL PARK

Fig. 75. This outline map of the Great Smoky Mountains National Park area is reproduced from the U. S. Geological Survey Topographic Map and keyed to indicate location of points of interest in and around the park, and more prominent land-marks. The Tennessee-North Carolina boundary line is shown extending across the park, and about equally dividing it between the two states. The total area of the park extends about sixty miles east and west, and about thirty miles north and south at the widest point. The key figures indicate: 1, Knoxville, Tennessee; 2, French Broad River; 3, Sevierville, Tennessee; 4, West Fork Little Pigeon River; 5, Gatlinburg; 6, Mount LeConte (6580 feet); 7, Mount Guyot (6636 feet); 8, Indian Gap; 9, Clingman's Dome (6680 feet); 10, Sugarland Mountain; 11, Thunderhead; 12, Rich Mountain; 13, Cade's Cove; 14, Gregory Bald; 15, Pisgah National Forest; 16, Balsam Mountain; 17, Bryson City, North Carolina; 18, Pigeon River; 19, Tennessee River; 20, Little River; 21, Norton Big Trees; 22, Maryville, Tennessee; 23, Little Tennessee River; 24, Tuckasegee River; 25, Little Pigeon River.

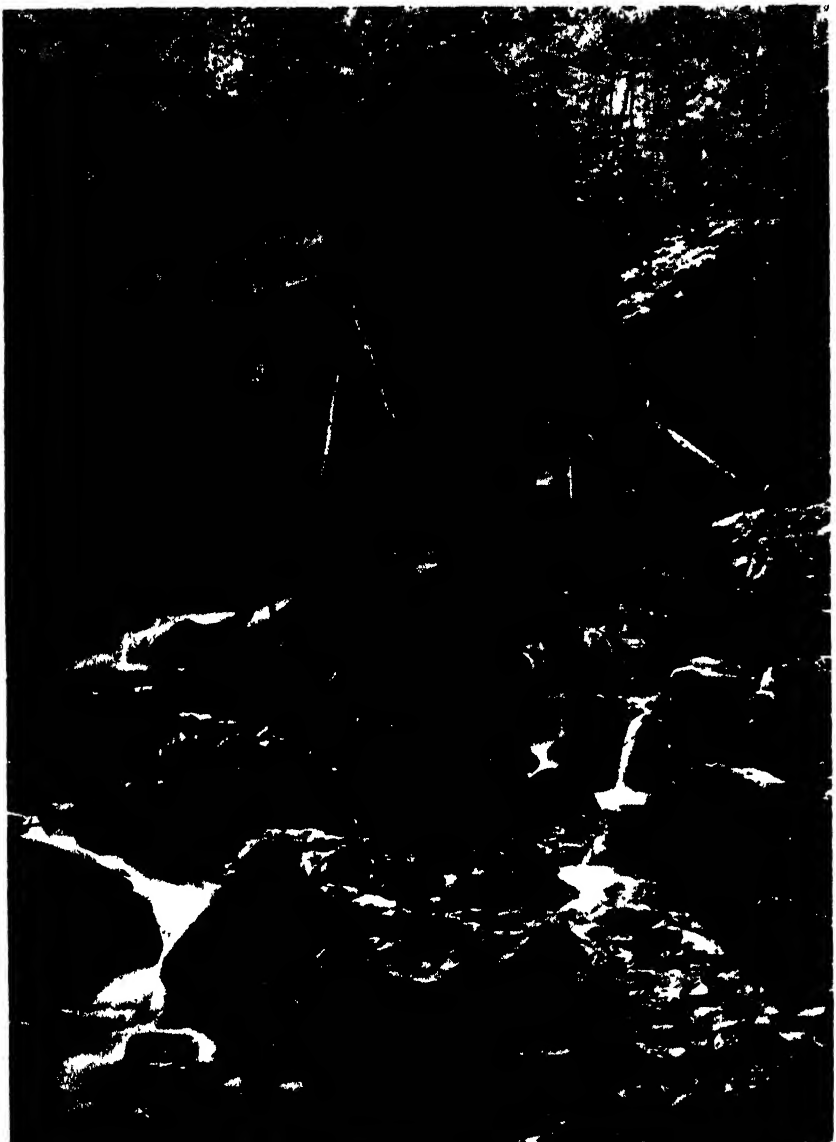


Fig. 76. The old grist-mill, in Cherokee Orchard, is an ideal relic of pioneer days. Numerous large boulders partially covered with moss are prevalent throughout the Chestnut Zone. Photograph and copyright by James E. Thompson.

Fig 77 Water falls and small rapids intercept the stream forming whirlpools and eddys where salamander larvae abound under decaying leaves near the water s edge A scene in the Chestnut Zone Photograph and copyright by James E Thompson

Fig. 78. Rainbow Falls marks the end of the Transitional Zone, and is the only natural barrier in the entire stream The altitude at the top is 4,325.6 U. S. BM. The water makes a plunge of eighty-five feet The photograph was taken after a heavy rainfall. Photograph and copyright by James E. Thompson.

Fig. 79. Giant ferns and birch trees cover the side of Gregory Bald. This scene is typical of the Birch Zone of Mt. LeConte. Photograph and copyright by James E. Thompson

The trail leads along the east side of the stream the entire length of the Transitional Zone.

Birch Zone.

This zone includes the next three plots, and is composed of birch, buckeye, balsam, spruce, white maple, viburnum, and rhododendron. The trees are larger and not as thick in the lower altitudes as they are higher up in the zone. In the openings there is a variety of flowering plants. Moss and ferns are prevalent.

At Rainbow Falls the stream is wide and as one ascends it becomes narrower and swifter, having a fall of 32 percent. The falls are larger and the rapids more frequent than in any other zone.

In general the valley becomes somewhat narrow, and the slopes very steep. The large boulders and cliffs are partially covered with moss and ferns. About a third of the way, a small stream flows from the west. Here the valley is somewhat wider. At the upper end of the zone there is a small western cove, from which flows another stream. Here a small delta has been formed upon which are a few large trees.

The trail crosses the creek twice in the Birch Zone.

Balsam Zone.

This zone includes the last three and one-half plots of our area. It is composed of balsam, spruce, red cherry and white ash, which are typical of Canadian forests. Balsam is by far the most abundant. The trees are so thick that the ground is continually shaded. White maple, viburnum, and huckle-berry shrubs are prevalent on the crest. After a short transitional section the ground is completely covered with fern-moss, sorrel, and ferns.

Here we find the stream steepest, having a fall of 34 percent. After a few hundred feet there are very few large boulders and high cliffs. The stream is fed by a large number of seeps a few hundred feet from the crest, which is directly between Main Top and West Peak.

After a few hundred feet the valley widens extensively and forms a long gentle slope.

Near the top the trail leaves the stream and leads directly east one-half mile to LeConte Lodge.

Summary.

According to the United States Biological Survey, Fourth Provisional Zone Map, the forest ranges from the Transition to the Canadian. The summit is covered with fir, typical of this zone. Sphagnum, fern-moss and ferns completely cover the ground. As one descends the mountain the deciduous forest appears, principally birch and buckeye. Replacing these at a lower level are the chestnuts and oaks.

The stream is classed hydropsyche, containing numerous falls, rapids, large boulders, a few deep pools and shoals.

The entire valley contains virgin forest, flowering shrubs, and plants. The slopes are steep, containing many cliffs practically covered with moss and ferns. Numerous boulders are exposed along the valley for the most part.

The best approach to Mt. LeConte is by way of Cherokee orchard where the last residence is left behind. For more than three miles a trail, too rough and steep for pack horses, follows LeConte Creek to a small lodge on the summit.

V. The Problem.

So little attention has been given to the fauna of this region from an ecological stand-point that any comprehensive attempt on my part would seem futile. Nevertheless, there is an unusual opportunity to study life, environment and heredity in its natural state undisturbed by the agencies of man.

Mt. LeConte is typical of the whole region and this section was selected for the present survey.

The problem chosen for this report deals only with the salamanders, and is two-fold: First, to determine the number of species found; and second, to determine the distribution of the different species.

VI. Technique and Methods.

During the winter months numerous trips were made to Mt. LeConte and winter conditions were studied. During this time

plans were formulated for the survey. On May 15, temporary headquarters were made above Rainbow Falls. Through the coöperation of J. Walter White and R. F. McClure the entire stream, beginning at the Cherokee Orchard and continuing upward to the point directly between Main Top and West Peak, was surveyed and plotted. A United States Engineering compass was used to secure the calls. An ordinary chain was used to measure the distance. At the end of each thousand feet the pressure and altitude were recorded. The data were made with an aneroid barometer checked at United States Bench Marks. A metal tag, with the plot number, was tacked to a tree at the end of each plot. So far as was possible all collections were made under uniform weather conditions. The time consumed at each plot was approximately equal. The animals were collected in their natural habitats without the use of trapping, baiting, or any method of congregating them.

A dip net was used for specimens found in the stream. Adult specimens were found near the stream by turning over stones, logs, and moss. The animals from each plot were collected and preserved in separate jars or vials in ten percent formaldehyde. Each container was labelled, giving the plot number and date.

The following table shows the distribution of salamanders collected along LeConte Creek. The figures at the top indicate the plot from which the salamanders were taken.

TABLE I.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Desmognathus quadra-maculatus.	0	0	2	3	3	3	6	9	13	23	8	4	3	5	3	0	0	85
Desmognathus phoca.	1	0	2	0	1	1	1	1	2	2	0	0	1	0	0	1	0	13
Desmognathus fuscus carolinensis	0	2	1	1	2	1	1	2	2	2	3	5	1	1	2	3	0	29
Plethodon jordani.	0	1	0	0	0	1	2	1	3	1	1	1	2	5	8	13	19	38
Gyrinophilus danielsi.	0	0	0	0	0	0	0	0	1	0	3	0	2	0	0	0	0	6
Eurycea bislineata wilderae.	0	1	1	4	2	5	1	2	3	2	0	1	1	0	0	1	0	24
Desmognathus larvae.	3	9	7	19	30	32	26	20	19	29	2	8	2	3	2	1	0	212
Total.	4	13	13	27	38	43	37	35	43	59	17	19	12	14	15	19	19	407

VII. Discussion.

The Salamanders collected from this locality belong to a single Family, the Plethodontidae.

Desmognathus quadra-maculata (Holbrook).

These specimens are semi-aquatic, living in or near the stream, and when disturbed, plunge into the water and are difficult to collect once they hide under large rocks.

The first specimens were collected in Plot No. 3, at an altitude of 3150 feet. There is a steady increase in number of specimens encountered, to the end of the Transitional Zone. Rainbow Falls marks the end of the Transitional Zone, and is the only natural barrier in the entire stream. The altitude at the top is 4325.6 U.S. B.M. Here the water makes a plunge of 85 feet, and while the falls itself is only a few feet wide, the cliff is more than 300 feet wide. As many as 52 specimens have been counted lying upon the moist rocks by the observer at one time. Only a few specimens were observed above the Falls, and not any were found above an altitude of 6000 feet.

In the summer of 1930, 33 specimens were collected in the Transitional Zone.

Desmognathus phoca (Matthes).

This species seemed to be very evenly distributed along LeConte Creek. They are found most frequently in the water, but may be encountered some distance from the stream under the thick moss or bark of decaying logs.

Desmognathus fuscus carolinensis (Dunn).

This species is more or less terrestrial, and occupies the slopes rather than the streams. Occasionally one may be taken from or near the stream. They, like Desmognathus phoca, seem to be very evenly distributed along LeConte Creek.

Plethodon jordani Blatchley.

This species is found only in the Great Smoky Mountains. It occupies the tops of many of the highest peaks. It is terrestrial, and may be found under decaying logs and moss. The first was collected at an altitude of 3000 feet, but they are more abund-

ant above 5000 feet. Only a few were collected, but large numbers were observed under the moss from decaying logs. It is interesting to note the color variation of the red cheeks.

Gyrinophilus danielsi (Blatchley).

This species is not very frequently encountered. One larva was taken from the Transitional Zone, and five adults from the Birch Zone. The adult is very sluggish, and the five specimens were taken at night near the stream, at an altitude of above 5000 feet.

Eurycea bislineata wilderae Dunn.

This species is the most attractive of the salamanders in the collection. It is very evenly distributed along the stream. They are terrestrial, living under rocks and decaying logs.

Larvae.

A large number of larvae was taken from the water. They abound in the shallow pools under fallen leaves, and are most abundant in the Chestnut Zone.

VIII. Summary.

This paper contains a brief description of the Great Smoky Mountain area, emphasizing its unparalleled variety of flora, and listing a large number of its fauna. A more detailed description of Mt. LeConte and LeConte Creek is given together with photographs illustrating the vegetation of various Zones.

The problem and procedure is clear. The results are based on observations and collections of more than four hundred specimens of salamanders.

1. Six species belonging to four genera, and a single Family, were found in the section studied.

2. The distribution of the salamanders collected are tabulated in Table I. Conclusions based on this Table are as follows:

a. *Desmognathus phoca, Desmognathus fuscus carolinensis,* and *Eurycea bislineata wilderae* appear somewhat evenly distributed throughout the area studied.

b. *Cyrinophilus danielsi* is rare, and those collected were taken only at night near the camp.

c. *Desmognathus quadra-maculata,* the most abundant of all the salamanders, is largely confined to altitudes between 3000-5000 feet.

d. The little known red-cheeked salamander, *Plethodon jordani,* is largely confined to altitudes above 5000 feet.

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Fig. 80 **Above:** The LeConte Lodge is located on the summit of Mt LeConte Hikers find this a haven of rest after a long climb up the mountain side Fig 81 **Below:** Dense growth of balsam shadow the ground where fern-moss forms a carpet more than a foot thick. Note the decaying logs where numbers of red-cheeked salamanders *Plethodon jordani* may be collected.

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Fig 82. Tall trees crowd the forest to the water's edge high in the Balsam Zone of the Great Smoky Mountains. Photograph and copyright by James E Thompson

NOTES ON CERTAIN BIRDS OF PARADISE*

By Lee S. Crandall

Curator of Birds, New York Zoological Park

The following notes represent a rather miscellaneous collection of personal observations on various birds of paradise living in the New York Zoological Park. No attempt has been made to present complete accounts of the species mentioned. Some of these birds were collected by the New York Zoological Society's expedition to New Guinea[1] in 1928–9, in which Mr. J. E. Ward and the writer participated. Others have been gathered from various sources, usually through dealers, so that, beyond the known range of the form in question, there is no means of determining exact localities.

Prince Rudolph's Blue Bird of Paradise

Paradisornis rudolfi Finsch

My notes on the curious, inverted display of the male of this species have already been printed.[2] Displays by female birds of paradise, while unusual, are not unknown and I have the following description of such a display by a female blue bird of paradise, made on March 19, 1923. The sex of this bird was later confirmed by post-mortem examination.

Hanging upside-down from top of cage, legs fully extended. Wings slightly spread, breast feathers expanded laterally, just projecting beyond wings, and turned slightly forward. Tail pressed forward, between legs, until nearly horizontal. Head not turned upward as high as cock's in display, and eyes not closed. Vibrated backward and forward from hips, like the cock, and also occasionally drew her body upward to horizontal position. Also vibrated rapidly up and down, bending leg joints. Very persistent and almost impossible to disturb, although not ordinarily a particularly tame bird.

In general, this display of the female is similar to that of the male, but there are several striking differences. I have never seen

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[1] New York Zoological Society Bulletin, Vol. XXXII, No. 6.

[2] New York Zoological Society Bulletin, Vol. XXIV, No. 5, pp. 111–113, also "Paradise Quest" (1931) pp. 107–108.

a male move his tail into the horizontal position, or "vibrate up and down." During display, the male sings constantly, in a low, grating voice; the female was silent. I saw this female in action only once but she was observed on another occasion by a keeper. Neither of the females now in the collection has so far been seen to attempt display.

There is much confusion concerning the natural molting periods of the birds of paradise; no doubt differences in altitude, humidity and temperature account largely for conflicting statements. Blue birds of paradise taken at Deva-deva, Central Division, Papua, in October, 1928, were all in full plumage, with no indication of molt. These captive birds began dropping feathers in January, continuing the process of feather renewal normally. Once they have become established in New York, however, all birds of paradise that I have been able to observe begin the molt in spring or early summer. In some species, there appears to be a tendency to begin somewhat later in consecutive years, but there is not yet sufficient data on this point. I have the following dates for approximate beginning and completion of molt in an individual male blue bird of paradise:

Molt	began	June 16, 1930,	completed	October 14, 1930
"	"	July 7, 1931,	"	November 9, 1931
"	"	July 1, 1932,	"	November 8, 1932

These figures indicate a continuous molting period of approximately four months, which is confirmed by observations on two other males of the same species, during single years. The period of full courtship display coincides, naturally, with completion of the molt but display may take place even at the height of the molting period, when the bird is in very ragged condition. Presence or absence of the female appears to have little if any bearing on frequency of display.

Red Bird of Paradise

Uranornis rubra (Daudin)

I have never seen the display of this species. I have the molting period of an immature male now living in the collection: May 3, 1932 to August 10, 1932. This span of about three months corresponds to what seems to be normal here, for females and plumeless males of *Paradisaea*.

EMPEROR OF GERMANY'S BIRD OF PARADISE

Paradisaea guilelmi Cabanis

Two adult males of this species, purchased in London, arrived here on November 18, 1931. One commenced molting about December 10, 1931 and finished about April 20, 1932. The other was first noticed dropping feathers on December 17, 1931 and was in full plumage about April 30, 1932. This period of roughly four months is normal for plumed males of *Paradisaea*, as observed here.

This bird has at least two types of call-note. One resembles the usual call of *Paradisaea* males, very loud and piercing, in volume somewhere between *apoda* and *minor*, and delivered with the mouth wide open. The other is quite different from anything I have heard before. The bird draws himself erect, expanding the strikingly large green patch on the throat and breast. He then emits a soft, clear, *poop, poop, poop!*, throwing his head upward with each note and keeping the bill almost closed.

No signs of attempted display were seen until October 16, 1932. On this occasion, the bird was moving along a perch, then hopping to another, his body in a stiffly horizontal position, head and neck extended, beak turned down. He was "bobbing" slowly up and down, from the hips. He then spread the wings in the horizontal plane, and vibrated them very rapidly. The flank plumes were slightly spread vertically, and raised somewhat above the line of the back. This continued at intervals for about ten minutes.

On October 25, the same bird was seen giving the loud call, then "bobbing" along his perches as described above. He then called again, four times, and leaped to his favorite perch. His body became rigid, in the horizontal position, the head and neck extended forward and slightly down. The flank plumes were held as described above. The wings were suddenly spread and flicked forward, so that the upper surfaces were toward the bird's head. This pose was held for about five seconds, when the wings were snapped back into normal position. After being held there for another five seconds, they were again thrown forward. The bird repeated this flicking movement seven times, at about the same intervals, then threw up his head, called loudly and began moving about his perches.

On the morning of October 27, at about nine o'clock, the full display was seen for the first time. The bird went through the

"bobbing" and "flicking" phases of his display several times. Suddenly he called loudly, and turned head first under his perch, which he clutched firmly. The body was drawn up quite close to the perch, in a position nearly horizontal, but with the anterior portion somewhat lower than the posterior. The wings were fully spread and turned well up. The tail, also, was widely spread and turned nearly vertical, so that the long wires extended far above. The head and neck were fully extended and turned upward. The plumes were erected at an angle of about 45°, those at each side forming a semicircle, overlapping anteriorly and posteriorly to make a complete circle around the inverted abdomen. Each plume now appeared as a separate entity, the widely-spaced barbs being seen to great advantage. Head, wings and tail remained outside the circle, which enclosed only the feet, as they grasped the perch. The body was then moved slowly from side to side, with a slight rotary motion, causing the plumes to wave gracefully but not disturbing the general formation. The display lasted for about five minutes, during which the head, wings and tail were held rigidly in position. The bird made no sound during the period, at the end of which he returned head first to normal position. After an interval of about ten minutes, devoted to calling loudly and leaping with animation from perch to perch, he repeated the entire performance, including "bobbing," "wing-flicking" and the inverted climax.

Count Raggi's Bird of Paradise

Paradisaea apoda raggiana Sclater

The courtship display of this species is too well known to be described here. I have, however, a few notes on the molting period. A single adult male is recorded as beginning to drop feathers on the following dates: June 1, 1918; May 21, 1921; May 16, 1922; May 1, 1923. No notes of finishing dates were kept. Adult birds of each sex, taken at Deva-deva in October, 1928, were in full plumage. Of these, an adult male began his molt, while at sea, on February 26, 1929; he was in full plumage on July 1, approximately four months later. In 1930, he began on May 8, and was complete on September 20. In 1931, the dates were May 3 and September 10; in 1932, May 12 and September 21. The only dates I have for a female of this species are from April 20 to July 18, which is the normal expectation.

Lord Rothschild's Gorgetted Bird of Paradise

Astrapia rothschildi Foerster

Two adult males and a supposed female of this species were received from London on November 18, 1931. As soon as they had been placed in flight cages, it was noticed that the wings of the male make a distinctly audible rustling sound when in motion.

One of the males began molting about January 1, 1932, and was finished about May 1. The second bird started about January 15, and had completed the change by May 30. On May 17, 1932, the first of these males was seen for the first time in a phase of display. He stood erect on the perch, his tail pushed forward beyond the perpendicular and slightly spread. The dark blue gorget or breast plate was widely spread and flattened, its fiery golden margin glowing conspicuously. The green feathers of the breast were also expanded laterally. The bird remained rigidly in this position for about ten seconds, making no sound. A few days later, the same phase was seen, except that on this occasion the bird rapidly opened and closed the lateral tail feathers.

This form of display was seen almost daily until August 26, 1932, when a more complicated development was observed for the first time. The bird turned backward under the perch, at right angles to it, the body nearly horizontal, but the anterior portion slightly lower than the posterior. The head and neck were turned upward at one extremity, the tail at the other, so that the bird formed an approximate semicircle. The gorget and the feathers of the abdomen were widely spread, as before, the gold margin of the former being very conspicuous. The ear coverts were spread upward around the head, joining the elevated ruff on the nape. The wings were pressed tightly against the body, and the feathers of the back were expanded so as to partly cover them. The tail was held upright and widely expanded at first, then the lateral feathers were rapidly opened and closed, the middle pair remaining stationary. The display was enacted four times, at intervals of from four to five minutes, each period lasting from ten to fifteen seconds.

At no time during display was any sound heard. This species is strangely quiet, and the only note it has been heard to utter here is an occasional thin, jay-like *kak, kak, kak, kak!* which seems to function as either call or alarm note.

Long-tailed Bird of Paradise

Epimachus meyeri meyeri Finsch

An immature male and a female, apparently adult, of this form, were collected at Deva-deva, Central Division, Papua, in October, 1928 and landed in New York on March 29, 1929. The male appeared very young and we took him to be a bird of the year but this could not be definitely established. While still in immature plumage, he frequently gave a loud, rattling sound, reminiscent of the beginning of the call of the giant kingfisher or laughing jackass (*Dacelo novaeguineae*). In calling, the body was extended horizontally, with the mouth open. Violent paroxysms shook the bird, as the sound was literally shaken out. The female uttered only a single, plaintive yelp, which was given by the male also, when hungry or separated from the female. The alarm note is a deep, guttural grunt, delivered by both sexes, with rapid jerking of wings and body. These notes were continued when the birds were fully adult.

Both birds were in molt when landed in New York, but no notes of dates were made. Both were noted as dropping feathers on March 15, 1930 and both were recorded as completely finished on June 15, 1930. The tail of the male now appeared to be slightly longer and his general color somewhat darker than that of the female. He was also, by now, distinctly larger than his mate but aside from these points, the sexes were similar.

On April 5, 1931, both birds again began the molt. The female was finished by July 10 but this time the male required a longer period. On May 15, it was noticed that black feathers were appearing in rump, wing coverts and thighs. By June 15, the lower back, upper tail coverts, nape and the inner secondary on each side were black. A gray patch had appeared in the center of the breast and the two middle tail feathers, now black, had reached a length of about four inches. On September 10, the change was recorded as complete, including the flank plumes and the long pectoral shields. The tips of the middle tail feathers had become damaged, so that no measurement could be made. The change from immature plumage to the magnificent dress of the adult male had required a period of approximately five months.

In 1932, the male began dropping feathers on May 10, and was in full plumage by October 3, so that the period was again about five months.

Two forms of display were noted in the immature male. The most common was seen for the first time on September 13, 1929. The bird gave his rattling call, then turned his body so that his breast was directed upward, his feet retaining their original position on the perch. The breast feathers were spread as widely as possible (which is not very much in the immature bird), lapping over the tightly closed wings. The tail was partly spread. This position was held stiffly for about ten seconds; the bird then moved rapidly about the cage, returned to the original spot and repeated the display. When not in molt, the bird went through this performance many times daily. Usually, the bill was kept closed; very rarely, it was widely opened, displaying the bright yellow lining of the mouth. Once only, I noted that the lateral tail feathers were vibrating rapidly.

On a single occasion, a quite different form of display was seen, while the bird was still in immature plumage. It has never been noted since. The bird was in an upright position, with the breast feathers spread. The tail was jerked wide open, then tightly shut, the alternation being very rapid. The wings, which were closed against the body, were moved up and down along its sides, the upward movements coinciding with the opening of the tail. The display was continued for a minute or more so that, fortunately, I had opportunity to observe it fully.

After the male had assumed adult plumage, he was first seen in display on October 14, 1931. It was the common inverted form, most used by the immature bird, but now become more complicated. Standing normally on the perch, the bird expanded the feathers of the breast, taking some time to arrange the short decorative flank plumes, which extended outward, forming a fringe around the sides. He then gave his rattling call and turned the breast upward, his feet retaining their original position. The breast feathers were now spread to their fullest extent, the bird's body appearing flattened. The short feathers of the upper breast turned upward about the head, circling the throat so closely that the iridescent black of face and throat became very conspicuous. The wings were closely folded and the tail was slightly spread, though not vibrating or moving. The beak was closed. The long pectoral shields were folded beneath the plumage, so that they were entirely invisible. (They take no part in this form of display.) As in the immature stage, this pose

was held rigidly for about ten seconds, when the bird returned to normal position.

Later on, a second form of display was used by the adult bird, quite different from anything that had been seen before. In this phase, the bird sits in a normal position, ostensibly preening the loosely extended breast feathers and pectoral shields. Suddenly, without calling, the body is drawn erect, with tail very slightly opened, wings tightly closed. The breast feathers, encircled by the decorative flank plumes, are widely spread. The pectoral shields are thrown straight upward, so that they extend far above the head, wrapping it closely. At the upper extremity, the shields are narrow and compressed; at their bases, they broaden gradually, to pick up the line of the spread breast feathers. The beak is widely opened, to show the bright yellow lining of the mouth. This position is usually held rigidly for about five seconds, when the bird resumes his alternate preening and displaying.

On rare occasions, usually very late in the evening, a further development of this display has been seen. Stiffly maintaining the upright position just described, and with the feet firmly grasping the perch, the bird rotates his body in a series of short jerks, pausing for several seconds at the end of each, until it is at right angles with the axis of the perch. He then jerks slowly in the opposite direction, until he has again come to a right angle with the perch but is facing the other way. This movement may be continued for from two to five minutes. Throughout, the bird is obviously exerting himself to the utmost to maintain his tense attitude. There is no movement of tail, wings or plumes, and no sound, once the position has been struck.

Lesser Superb Bird of Paradise

Lophorina superba minor Ramsay

I think I can add nothing to what is already known of the display of this bird. In addition to the rather harsh *ka-a, ka-a, ka-a,* which is given by the male in calling and displaying, both sexes use a series of rather sharp thin notes, rapidly repeated, when alarmed. This call is also used in the evening, at perching time, the sexes joining in chorus. At such times, it is noticeable that the voice of the female is distinctly higher and thinner than that of her mate.

Many species of this group cannot be kept in pairs in small quarters but male and female of this form agree well together. They frequently indulge in "tickling," the sexes alternating in working through the head and neck feathers of the companion. I have not noticed this habit in any other bird of paradise.

Most birds of this species collected at Deva-deva, in October, 1928, showed no signs of molt but I have notes of two males, one adult and one just coming into color, that were molting heavily at that time. A young male taken at this time was in the typical intermediate plumage resembling that of the female but interspersed with patches of black. About April 1, 1929, this bird began the molt and by September 1 was in full adult plumage, including full cape and breast-plate. Beyond the facts that full color was assumed in a single molt, after the intermediate stage, and that the time required was about five months, nothing of unusual interest was noted. A female beginning at the same time (April 1) was finished about July 1, establishing uniformity with the molting period of the females of all species noted.

On April 5, 1930, the male noted above was again in molt, beginning with the dropping of the cape feathers of the back, and the tips of the green breast-plate. Because of suspicion of some peculiarity, the bird was caught and examined on July 5. The body feathers had completed their growth and those of wing and tail were just finishing. Observation had shown that the iridescent feathers of the crown and the center of the breast-plate had not been dropped. On the nape, the space from which the cape was to grow, was completely bare. At each end of the breast-plate, was another bare space. The plate was represented only by the small central feathers, the whole being about one and one-half inches across. About August 1, the feathers of the crown and central breast-plate, began to drop, new ones beginning to grow immediately. The bare patches previously noted were still present. On August 15, it was seen that these spaces were filled with heavy blood quills. These grew very rapidly, so that by September 10, the entire molt was considered to be complete.

In 1931, the molt of this bird began about May 7 and was completed by October 5; in 1932, the dates were May 28 and October 24, the periods again being approximately five months for the third and fourth successive molts. The same delay in renewal of the ornamental plumage was noted, as in 1930.

In a fully colored male, taken at Deva-deva in October, 1928, and showing no sign of molt at that time, the cape and tips of the breast-plate were missing, and the spaces they should have occupied were bare. This bird died before new growth began but the instance seems to confirm the delayed renewal as normal for the species.

LAWES' SIX-PLUMED BIRD OF PARADISE

Parotia lawesi lawesi Ramsay

and

GREATER SIX-PLUMED BIRD OF PARADISE

Parotia sefilata (Pennant)

I have been able to note no difference in the display forms of these two birds; I have already given a description of the dance of the former.[3]

The only sound I have heard made by males of *Parotia sefilata*, is a harsh squawk, usually a single note but sometimes repeated so rapidly that, except in quality, it somewhat resembles the full call of *Paradisaea*. *Parotia l. lawesi* uses the same note, though somewhat softer. The latter also makes a soft, trilling sound, *treet, treet, treet*, rapidly repeated and with a rising inflection, more commonly heard at perching time.

My only record of the molting period of *Parotia sefilata* is one for an adult male, the period running from May 5, 1930 to September 6, approximately four months. There are two for a male of *P. l. lawesi:* April 21, 1930 to August 18, and April 8, 1931 to August 1. Each is roughly four months. I have no data for females. Birds of each sex taken at Deva-deva in October, 1928, showed no indication of molt.

STOMACH CASTS.

On several occasions, pellets of matted food detritus, cast by the lesser superb bird of paradise, have been observed. This regurgitation has not been noted in other species, though it may occur. These pellets had no covering and did not appear to differ from those commonly ejected by other passerine birds.

[3] "Paradise Quest" p. 99.

Casts of another nature have been recovered in several species, as follows: *Paradisaea apoda raggiana,* June 24, 1929, and two more from the same bird within the next few weeks; *Parotia lawesi lawesi,* December 1, 1930, January 3, 1931 and April 6, 1932; *Lophorina superba minor,* January 2, 1931. All cases cited are of adult males. These casts were in the form of sacs, sometimes containing food detritus but usually empty. Their shape, size and heavily corrugated folds led to the supposition that they were formed by a shedding of the inner lining of the gizzard. Histological examination by Dr. Charles V. Noback, Veterinarian of the Zoological Park staff, confirmed this opinion.

In most cases, the casts were dry and shriveled when found. In two instances, they were recovered almost immediately after regurgitation. One of these, from *Paradisaea apoda raggiana* measured 30 x 16 x 7 mm; the other, from *Lophorina superba minor,* measured 19 x 15 x 9 mm. Both were quite empty.

OBSERVATIONS ON THE LIFE HISTORY OF THE MARBLED SALAMANDER, *AMBYSTOMA OPACUM* GRAVENHORST

BY G. K. NOBLE AND M. K. BRADY

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(Figs. 83–93 incl.)

INTRODUCTION

The Marbled Salamander, *Ambystoma opacum*, is one of the commonest species of *Ambystoma* in the eastern United States. It differs from all other species of the genus in its habit of usually laying its eggs on land. This fact, first discovered by the Reverend Charles Mann in 1855, has excited the attention of herpetologists for many years. Many observations have been reported on the life history of this form, those of Dunn (1917), Brimley (1920), Bishop (1924), and Lantz (1930 and 1930a) being especially noteworthy. In 1929, while collecting in the vicinity of Washington, D. C., we discovered that great numbers of brooding females could be obtained under leaf mold on dry pond bottoms or on pond banks which later would be flooded. The fact that we could obtain eggs in large numbers induced us to repeat the work of previous observers and to examine certain additional features of the life history. We have already published a note (Noble and Brady, 1930) on certain phases of this work and in this paper we intend to put on record a summary of our observations extending over a period from October 1929 to November 1931.

In the course of the work we received assistance from several sources. We are especially indebted to Mr. Sam Yeaton, Mr. G. P. Engelhardt, and Mr. J. A. Weber for the opportunity of publishing their field notes, which are recorded below. Miss Margaret Harland has given us technical aid in the preparation of the material and we are indebted to her for the microphotography.

Fig 83. Marbled salamander brooding her eggs The cover of moss has been removed but the female has not changed her position. The female usually lies adjacent to the egg mass while brooding and rarely does the tail cover the egg mass as shown here. Photographed at Miller's Place, Long Island, by S. C. Yeaton.

Breeding Time and Place

The eggs of *A. opacum* have been collected during all the fall months. The Reverend Mann (1855) found eggs at Gloucester, Virginia, in November and December. McAtee (1907) gives September and October as the months during which this species is found with eggs in Monroe County, Indiana. Brimley (1920) records eggs in October and November in the region near Raleigh, North Carolina. Dunn (1917) found fresh eggs at Mt. Vernon, Virginia, September 21, 1916. Deckert (1916) records eggs with developed embryos from Silver Lake, Westchester Co., New York, September 25, 1913. Bishop (1924) took two sets of eggs at Raleigh, North Carolina, on October 26, 1923. Eggs which we collected from October 3 to 6, 1929, in the Washington region had already undergone considerable development. On Long Island during 1931, egg-laying had occurred in damp locations by September 18. By September 20, most females discovered were with their eggs (Fig. 83). On the other hand, Mr. G. P. Engelhardt writes us that he has had a female under observation in the field at Hartsdale, New York, which laid eggs between October 2 and 4, 1931. It may be concluded that both in the New York and in the Washington areas egg-laying may occur in the field as early as September 20; in Westchester County it may occur as late as the first week in October. Females, which we brought from Long Island into the laboratory, laid eggs as late as September 28, 1931. Lantz's

specimens which were collected in the Washington area laid eggs in England on October 10. Mr. J. A. Weber has reported to us his discovery of six clutches of eggs with attendant females at Greensburg, Louisiana, October 25, 1930. From the form of the eggs he assumed that they had been laid recently.

Until the time we began our work with *A. opacum* it seemed that most eggs of the species had been discovered under logs or similar coverings by the edge of ponds, or more often under similar materials lying in hollows which later would be filled with rain water. Consequently we were interested to discover that the species lays its eggs far more frequently under dead leaves or grass in regions which later will be inundated. Several of these breeding sites may be considered in detail because the species will doubtless be found abundant elsewhere among similar surroundings.

In the Washington area the two localities studied during 1929 differed considerably in physiography. The breeding ground at Oakwood, Virginia, was in the dry bed of a temporary pond on one side of a railroad embankment. The region we studied covers about one-quarter of an acre and is of relatively recent origin. It is filled to varying degrees with rain water from December to June. The Rock Creek Park territory investigated was formed by the dry banks of a permanent pond, exposed by the autumnal drought. The terrain of both sites consisted of a layer of matted grass and leaf mold, covering a rather plastic clay. Much effort was spent at Oakwood in turning over logs. However, since but two nests were secured this way, in a spot where the form was known to be abundant, it was decided to investigate the mat of leaf mold which covered the lower areas of the pond floor. When this was rolled back a great ramification of tunnels was exposed. The mat of leaf mold had formed the roof of these tunnels. At various points along these runways, such as depressions or blind wings off the main corridors, the egg-clutches with attendant females were observed. The depressions or burrows containing the clutches were never very deep and the eggs were visible the moment the leaf-mold roofing was removed. Clutches were found occasionally around the entrances of holes, presumably made by crayfish, which opened up into the tunnels, and a few eggs were found within the holes. There was no evidence that the female had pushed or carried these eggs into these deeper tunnels, since the greater mass of every clutch was always found in the surface depression under the leaf mold. It was apparent, however, that the female had something to do with the shape of the immediate depression in which the eggs were deposited. In the majority of cases the area surrounding the eggs had the appearance of having been smoothed out and the edges of the depression quite often shelved out over the egg mass. Lantz says his female "slightly excavated the ground under a creeping plant" in the terrarium. It cannot be said with certainty that the depressions and tunnels found in the clay subsoil were originally made by the females. The soil was relatively resistant and could not be easily scooped out by a salamander. It seems more probable that most of the tunnels originally were made by some other agency but apparently they owed their smoothed-out and well-worn aspect to the activities of the brooding females. Unfortunately the ability of the females to excavate their nests in the hard clay could not be determined in the laboratory since our specimens had all laid and in the absence of any greater impulse were

content merely to tunnel in the moss and overlying debris of the terrarium. In some instances the nests were made in very faint depressions unconnected with any of the surface tunnels. Three such nests found at Oakwood had broad, well-smoothed edges and it is quite possible that they were excavated by the females. Several males and one spent female were found around the edges of the nesting area at Oakwood. None of these had excavated chambers such as those in which the eggs were found.

The selection of the nest site itself apparently involves the presence of a certain amount of moisture in the substratum and a cover of dead leaves or other material. At Oakwood the nests were not distributed evenly over the entire floor of the pond but were found clustered together in spots. These places usually were around the bases of alders, or along depressions made by drainage from the forest floor above the pond. Such places were more moist and had more leaf-mold covering than had other portions of the pond bottom. Clusters of from twelve to twenty nests would thus be found in certain favorable spots. In the Oakwood section one area 300 cm. long and 60 cm. wide, between the bases of two alders, yielded eighteen nests. Another area 150 cm. square yielded twenty nests. In some cases it was impossible to separate the clutches, two or three masses being confluent along the burrow floor. In the Rock Creek station a small area 109 cm. by 62.5 cm. contained seven nests, while a carefully examined area of 18 meters square on either side yielded but three nests. Here it may have been a question of cover. The leaf mold was thickest in the area in which the seven nests occurred. Further, this small area was situated on the steep slope of the pond side, three of the nests being found 109 cm. from the edge while the others were strung out between this point and the edge. There were no nests on the flat surface of the forest floor above. This seems to indicate that low depressions are not invariably selected, but that the character of the cover and degree of moisture are important factors in the selection of the breeding site. Invariably the nests were in an area later to be submerged by the early winter level of the pond.

Our method of hunting for the nests was as follows: On moving over the surface of the ground on hands and knees we would feel for a slight "give." This would indicate the presence of a burrow mouth or depression under the leaves. As such situations usually contained nests, our hunting on October 4 consisted of feeling for such spots. The method of feeling for nests was finally abandoned because we found that pushing in the nest roof tended to disturb the brooding female. We first developed a much better method while studying one of the ponds at Coram, Long Island, during 1930. Here the water vegetation had become matted down and dried during the summer drought. Standing in the deeper parts of the depression, we cut a strip of this matting three or four feet wide and rolled it back towards the higher ground. A great many nests were found scooped in shallow depressions in the dirt floor of the pond, and were fully exposed as the matting was rolled back.

Mr. Sam Yeaton has examined other localities on Long Island where other methods of hunting had to be employed. His field notes are also of interest in indicating the importance of humidity in regulating the nesting site selection. At Lake Grove, on September 18, 1931, he found:

"The bottom of the pond was sandy, very dry and barely covered with humus. Thirty adults were found, usually in small groups in the side of tunnels formed by mice or possibly by the salamanders themselves. Most of the salamanders were about three inches below the surface of the sand. No eggs were found here, although we found over twenty gravid females. Two specimens were discovered about six inches from the ground in the low branches of shrubs. A female with a nest of eggs was found the same night at Coram near a small back-water between Coram and Middle Island.

"On September 19, 1931, eighty-three adult *opacum* were caught at Jones Pond, Miller's Place. Only a dozen of the females were brooding eggs but the remainder were swollen with eggs. The brooding females had scooped out shallow depressions beneath the sheets of matted grass where the ground was still moist. The bottom of this pond was very flat and the nests were scattered all over the pond floor and not concentrated at certain levels as is the rule in the case of nests in dry ponds having steeper banks. In many cases the males and females were found together. Some of the depressions in which the eggs lay were natural irregularities of the pond floor but others apparently had been dug by the female. Some of the females without eggs had dug shallow depressions and apparently were preparing to lay eggs in them. On April 4, 1931, Mr. Jay A. Weber and I dredged this area without finding any *opacum* larvae. This would indicate that the adults had not laid here the previous fall in spite of their present abundance.

"On September 21, 1931, near Melville, Long Island, thirty-three adults were collected, mostly brooding females. Many females with eggs were on a moist bank in depressions made by the hoofs of cows. On September 18, we had visited the same locality and found no eggs. Males were found wandering in damp places near the border of the ponds while the females were restricted to suitable breeding grounds."

These data indicate that the female *opacum* may change her breeding site from season to season according to the degree of humidity present in any one locality. The largest number of brooding females collected by Mr. Yeaton during 1931 was obtained under sheets of grass or other vegetation in situations similar to those at Coram. In 1930 at this locality we also found females brooding their eggs under sheets of sphagnum. In 1931 Mr. Yeaton collected forty-two adults in this habitat. The females in one area showed a decided preference for sphagnum covering the roots of fallen trees. The nest level averaged 30 cm. above the dry swamp bottom but because of the pitch of the surrounding banks these roots would be inundated by the first heavy rains.

Mr. Yeaton made an especial effort to collect migrating *opacum* for it was obvious that some specimens could not have been in their breeding sites all summer. On September 19, 1931, near Miller's Place, Long Island, he found one gravid female beneath a stump on a gravelly hill-side about 180 m. from water and on the other side a road separating it from any marshy places. Another specimen was discovered on the same day about one and one-half miles from the nearest water. There was a dry pond about 60 m. from this place but it could not have held more than 30 cm. of water or have been more than 450 cm. square. No salamanders were found in this dry bottom and it is doubtful if the captured female would have laid her eggs there.

In 1932, after the present manuscript had been submitted for publication, Mr. Yeaton made another visit to Miller's Place with a view to observing a more extensive migration of *A. opacum* to the breeding areas. In this he was unsuccessful, but on September 9 he collected at Miller's Place no less than eighty-five males without finding a single female. There were no eggs or females in this area which he knew from previous experience would be later occupied by brooding females. Two days later the first females were captured in this area. It is therefore clear that the males of *A. opacum,* like the males of *A. maculatum,* precede the females to the breeding sites. This precedence of the males over the females appears to be the rule of many migratory salamanders as well as of frogs, of birds and of some mammals.

These data, although scanty, indicate that both sexes of *opacum* migrate to suitable breeding grounds about the middle of September, the males arriving before the females. The eggs are laid on land in moist situations. If the locality is very dry, egg laying does not occur. Possibly the adults move on toward more suitable situations. We have seen no evidence of a mass migration such as occurs in *Ambystoma maculatum.* Since courtship, as we shall show below, is not performed by great numbers of individuals at one time such mass movements would not be expected.

The courtship of *A. maculatum* occurs in the water. This species does not appear to be better fitted structurally for aquatic life than does *A. opacum.* We were interested in testing the reactions of the latter species to submergence, for it seemed possible that these reactions might throw some light on the breeding behavior of the species. We carried out our first experiments in the field.

At the Rock Creek station a brooding female was placed in water several centimeters deep and was observed to swim clumsily to the surface, endeavoring to keep her head out. She swam in various directions but upon reaching an object which provided a foothold she immediately climbed out of the water, instead of seeking to escape under the submerged leaves and debris as *Ambystoma maculatum* would have done. In the laboratory, the behavior of *A. opacum,* both male and female, when placed in water 10 cm. in depth, were in marked contrast to the behavior of *A. maculatum* and *A. tigrinum,* under the same circumstances. *Tigrinum* was found to swim readily about the tank, eagerly accepting food offered to it under water. *Maculatum* was equally at home in the water, although it was not capable of the same ease in swimming. *Opacum,* however, under these circumstances, showed signs of distress, swimming violently and clumsily about the tank, endeavoring to escape by climbing movements of the limbs. Three pairs of *opacum* were placed in a tank with a water depth of 2 cm. and provided with a stone shelter, the top of which was near the surface of the water. Under these conditions the animals were always able to keep their heads above the water and walked leisurely about seeking an escape, when they were not resting on the stone work. Next day the water depth was increased 3 cm. The animals immediately made a more violent effort to escape, striving to keep their heads above water. When the depth was increased to 15 cm. two of the animals drowned; the remaining four, by dint of stretching up from the rock work, were able to continue atmospheric respiration. When the depth was reduced to 2 cm. the specimens moved about in a leisurely manner. Specimens

kept for a month in water having a depth of 2 to 3.5 cm. never became completely acclimated to that element, refused food and consistently endeavored to escape. From this it would seem that *A. opacum* is certainly not at home in the water and will drown if denied the opportunity to indulge in atmospheric

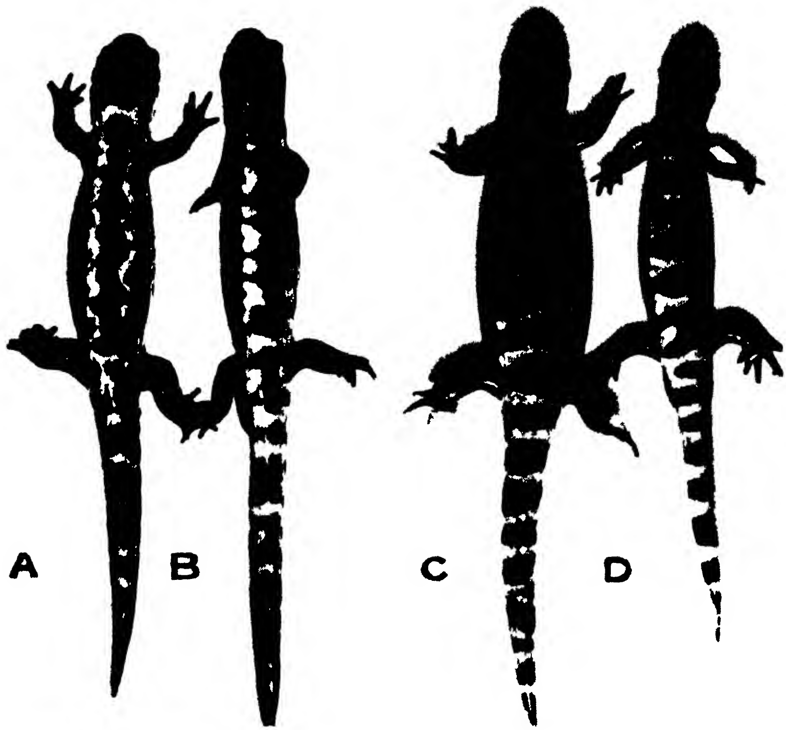

Fig. 84. Two pairs of *Ambystoma opacum* collected on Long Island showing extremes of variation in color pattern. Females (A and C) may be striped or cross-barred. Their color pattern does not distinguish them from the males (B and D).

respiration while in that element. It is certain that in nature the species never deposits its eggs in the water and that the female must desert her nest as soon as the pond basin begins to fill with water.

Sexual Differences in Coloration

Ambystoma opacum is unique among the species of the genus in exhibiting a consistent difference in color between the sexes during the breeding season. The white color pattern along the back is distinctly whiter in courting males than in females. Nevertheless, as indicated below, we have failed to find that this color difference plays any role in sex recognition or courtship.

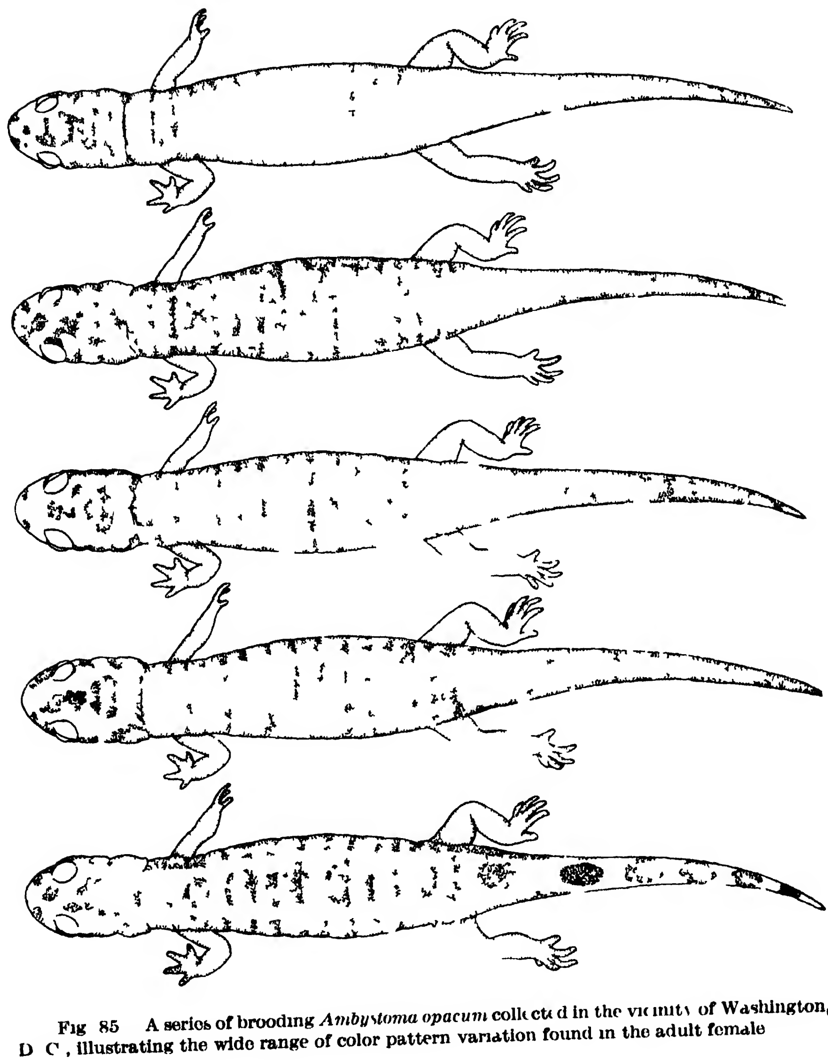

Fig. 85. A series of brooding *Ambystoma opacum* collected in the vicinity of Washington, D. C., illustrating the wide range of color pattern variation found in the adult female.

There is considerable variation in color pattern. Dunn (1917) found the females from one locality tended to exhibit more of a striped pattern than the males. The limited series of adults at Lantz's disposal were in agreement with Dunn's findings and Lantz (1930a, p. 64) has generalized as follows (translation):

"The original pattern, which may still be distinctly recognized in the female, is formed out of two stripes, which, beginning behind the nostril extend over the eyelids, parotids, neck and sides of the back to the tail. These longitudinal bands, especially on the neck and tail, are connected by a number of cross-bands, which in the female are ordinarily few; in the male, however, they can be so fully developed that nothing more remains of the original longitudinal pattern, in which the cross-bands on the sides of the body and tail either are not further joined or scarcely meet one another."

We have examined over five hundred breeding *A. opacum* and have failed to find any consistent differences in color pattern between the sexes. In figure 84, from among the three hundred and thirteen adult specimens collected on Long Island during the fall of 1931, we have selected individuals of both sexes with the striped and others with the cross-barred pattern predominant. Again, among the eighty-one adult females found guarding their eggs at Oakwood, Virginia, and Rock Creek Park, Washington, during October 1929, we have selected a series which shows nearly the complete range of color variation in the species (Fig. 85). The males collected in the same region fall within this range of variation. Both males and females may be either predominantly striped or cross-barred. We have found no consistent difference between the Long Island and the Washington specimens.

Courtship

Lantz (1930) was the first to describe the spermatophore of *A. opacum.* He found several attached to moss in a terrarium containing several adults. He writes, "As is well known, the marbled salamander breeds in the autumn, and the mating season appears to be quite short. In the two cases observed it was restricted to a few days in the first half of October. During this time unusual agitation prevailed in the terrarium after nightfall. The males were steadily pursuing the female, pushing her and rubbing their snouts against her body. They were also seen to chase each other in very much the same manner. Unfortunately nothing further could be observed, the animals' being so easily disturbed by light that even switching on a weak electric lamp made them soon retire into their hiding places. The actual procedure of fecundation remains, therefore, undisclosed."

Recently it has been emphasized that the evolution of courtship of the Caudata follows closely the phylogenetic scheme (Noble 1931). The courtship behavior remains essentially the same throughout a group of related species in spite of the radically different habitats such species may frequent. Plethodontids, whether aquatic or terrestrial, have the same type of courtship and the same has been shown to be true for certain natural groups of salamandrids. It seemed to us important to determine if *A. opacum,* a terrestrial species, had the same type of courtship found in the aquatic forms of *Ambystoma.*

Methods of Study

Our field observations on courting *A. opacum* were made from September 9 to 15, 1931, in the vicinity of Washington, D. C. These were supplemented by laboratory observations during the same period in Washington. From September 24 to 28, 1931, a series of Long Island specimens were observed under laboratory conditions in New York. Observations in the field were made by means of electric flashlights covered with red cloth. In the laboratory the entire illumination was provided by a series of photographer's red electric light bulbs of only 10 watt capacity.

Many of the salamanders were imprisoned on their courtship grounds by covering them with crystallizing dishes. Others were observed in courtship without such a cover. In the laboratories of the American Museum two or three pairs of adults were placed together in separate crystallizing dishes 20 cms. in diameter. Each dish was provided with several large pieces of damp slate, and was covered. The dishes were placed in shallow troughs of running water and the temperature regulated by the addition of ice. In the laboratories of the National Zoological Park the bottoms of the laboratory tanks were provided with soil from the breeding grounds. The soil was arranged to form either a flat surface or one cut by a series of interconnecting crevices and depressions, to simulate the conditions found in the dry bed of a pond. The soil was moistened to approximate natural conditions. Observations were made in Washington on segregated pairs and on groups of several pairs. Since many adults may be found together under the same log or pile of debris during the courting season, it is probable that group courtship is the rule in nature. However, the movements of individuals seem to be the same whether they are in pairs or in larger groups. Observations in the Washington area were made by Brady, those in the New York area by Noble. Our accounts were drawn up independently and found to agree except in certain details to be noted below. The discrepancies may be due to the fact that many of the Long Island salamanders had courted before reaching the laboratory. Brady, alone, observed the actual acceptance of the spermatophore by the female salamander, with her cloaca. Both of us observed spermatophores deposited by various males.

The Inception of Courtship

In the laboratories of the American Museum six to ten crystallizing dishes of adults were kept under observation at one time. During most of the period the salamanders either remained quiet or moved slowly over the damp stones. On several occasions the beginning of courtship was witnessed. One male would suddenly begin to dash rapidly about the dish butting his head against any individual he chanced to meet. This surprising activity would stir up the group and often another male would begin the same butting performance. A close examination of these active males revealed that they were usually endeavoring to push their snouts under individuals they chanced to meet. Their efforts were directed as forcefully towards other males as towards females. For example on September 24 at 8:45 P. M., one male was seen to butt his snout twelve times in rapid succession against the inguinal region of another individual which was proved by cloacal examination to be a male.

A female was never observed to begin a courtship and when butted by a courting male she exhibited less response than a male under the same circumstances. In attacking the tail of another salamander the courting male attempts to lift up the appendage with his snout but he usually strikes the tail in lowering his head after each lifting movement, thus giving it another rub. On several occasions a quiescent female was observed to arch her tail when this organ was butted by a male. This sometimes resulted in the male's working his way under the tail, or by turning he frequently crawled under the body. When two courting males met head on each tried to thrust his head under the chin of his opponent. The moment one male touched the chin of the opposite male with the top of his snout the opponent would jerk his head to the side and bring it with a vigorous thrust back under the chin of the first. The result was a head "fencing" conducted with such speed that the two heads appeared a blurr. To one familiar only with the slow movements of *A. opacum* outside of the breeding season, this show of agility was a startling performance. The behavior was witnessed three times on September 24, once on September 27, but has not been seen in the field.

Courting males may show a greater interest in other males than in females. On September 24 one male, after methodically thrusting his snout into the sides of a female for over a minute, turned toward a male and continued the butting movements with much greater vigor. Again on September 28 at 8:30 P. M. a courting male met another male and a female head on. The courting male rubbed the side of his head first against the male, and then against the female. He then turned and gave his full attentions to the male.

Lantz, as indicated above, found that courting males would pursue other males, and we have both confirmed this observation many times. This failure to discriminate between the sexes at the outset of courtship results in an increase in general excitement throughout the group. It has a mutually stimulating effect and brings more males into courtship at one time than would otherwise occur.

Courtship Postures

In addition to the butting and prying reactions there were several other types of behavior pattern which appeared many times both in the laboratory and in the field groups. If a butted individual attempts to escape, the courting male will frequently throw his hind legs and tail directly across the path of retreat (Fig. 86). The courting male with his body thus curled will usually continue to thrust his head into the side of the annoyed individual. The position is assumed not merely to trap the escaping salamander but to stimulate it further. With every head thrust the male will often jerk his pelvic region toward the snout of the pursued salamander, with the result that the latter receives almost simultaneously a push in the side and a slap across the snout. On September 28, one male was observed to butt a female nine times with his head while maintaining this position and jerking his pelvis toward her at each thrust.

In the field it appeared that the male was primarily interested in thrusting his head under the cloaca of the female. In the laboratory, however, males which had succeeded in assuming this position frequently worked forward under abdomen and chest, vigorously pushing up with the top of the head. If the

male had thrust his head under the fore part of a female he would frequently work back with the same lifting movements to the cloaca and beyond along the tail. Such movements often result in the female's being lifted from the ground and thrown to one side of the active male. Lateral rubbing movements of the

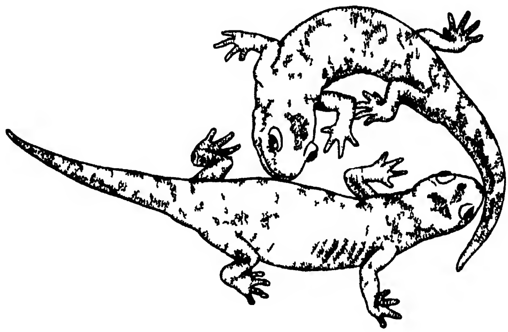

Fig 86 Courtship of the marbled salamander While butting the female in the side with his snout, the male blocks with his tail her escape

male's head may occur when he has thrust it under another individual. The lifting thrust may be accompanied also by side movements of the head. During the less active moments of the courtship the male may rub his cheek across the cheek of another individual. Females have been observed to respond in the

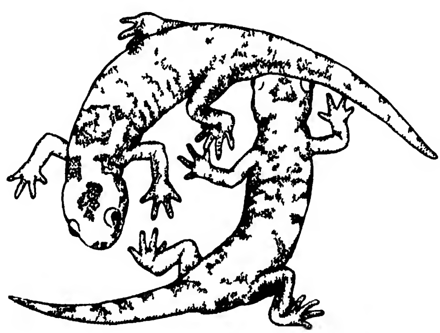

Fig 87 "The waltz" in the courtship of the marbled salamander The male (right) attempts to thrust his snout under the tail base of the female while the latter endeavors to bring her snout in contact with his cloaca The result is a rapid circular movement of the pair.

same manner. The female exhibits her rising interest in the attentions of the male by ceasing her attempts to escape and often by turning her head toward the male. In the field and in the laboratories of the Zoological Park it was noticed that the female frequently turned her head in the direction of the male's cloaca and attempted to put her snout in contact with it. This resulted in

bringing her own cloaca in front of the male's head. The male moving forward to reach the female's cloaca would withdraw his own and the movement continued would result in a circling "waltz" (Fig. 87).

In the laboratory, pairs of males were often seen to circle around in a "waltz," each attempting to thrust his head under the tail or cloaca of the opposite one. In Washington it was observed that if the waltzing salamanders were both males the movement did not continue very long. Only twice was it found to exceed sixty seconds, while if the partners were of opposite sex it would frequently continue for several minutes. It seems probable that cloacal secretions of the female stimulate the male to continue the "waltz" for these extended periods.

Although a male usually attempts to crawl under a partner, he may scramble over. This is generally the case if he does not succeed in thrusting his head under one end of the other individual, in which event he sometimes scrambles over his partner to the opposite end. Although such movements are accompanied by more or less butting with the head, there is never a definite attempt to cover up the nostrils of his partner in the manner characteristic of plethodontids (Noble and Brady, 1930a). However, in the course of a scramble a male may bring his chin over the snout of a female. Sections of this chin skin show that no hedonic glands (cf. Noble, 1931, Fig. 49) are present. Hence the stimulus of this phase of the courtship is mechanical rather than chemical.

The Taking-up of the Spermatophore

We expected to see the spermatophore produced at the climax of the courtship. This was not always the case. For example, on September 27 at 7:45 P. M. the following was recorded:

"Male slowly approaches another male and undulates the base of his tail. He butts side of the male and then turns to a female, slowly rubbing the upper portion of her side, and works towards her tail. During this procedure the male's tail is undulating rapidly. When he reaches the female's tail, he raises his body on legs held stiff and straight and slowly extrudes a spermatophore. Then the male turns and butts the opposite side of the female. After a moment's rest the male turns to another male and butts him with far more vigor than he displayed with the female. A second female passing attracts his attention and he continues vigorous thrusting against her."

The undulation of the base of the tail invariably preceded the production of a spermatophore, although such tail movements also occurred at other times. The undulation sometimes ceased immediately after the spermatophore was deposited, but in other cases it was continued for a few seconds. In seventeen instances the undulation continued until a second spermatophore was produced. One male was recorded as producing three spermatophores one immediately after the other. In six of the eight occasions when spermatophores were taken up by the females of isolated pairs the acceptance occurred immediately following production. The female, moving directly after the male (Fig. 88), passed her chin and body over the spermatophore until the cloacal lips came in contact with it. In the other two cases, several seconds of nosing around transpired before the female snout came in contact with the spermatophore. Then she

moved her cloaca over it. In five of these acceptances the female was seen to undulate her pelvic region while her cloaca was directly over the spermatophore. In three other cases where the spermatophore was secured by the female, she was found to remain motionless over the spermatophore for several seconds. In

Fig 88 The deposition of the spermatophore In the final stage of the courtship of the marbled salamander the male deposits the spermatophore while the female is following directly after him If the female fails to secure the spermatophore head with her cloacal lips she may nose about until she has found it

one instance, the female, after covering the spermatophore a few seconds, moved a few centimeters away in the direction of the male. She then turned, and apparently smelling the floor, worked her way back to the spermatophore and resumed her position over it.

As previously stated, group courtship appears to be the rule in *A. opacum* because many pairs were found together. In several groups studied, both in the field and in the laboratory, some or all of the males involved produced spermatophores. The sufficiently stimulated female usually accepted the first spermatophore with which she came in contact. This was usually the one produced by the male whose cloaca she had been nosing. In twenty-eight recorded instances the female apparently became aware of the spermatophore by smelling it, since her snout was brought in contact with it before she moved over it. However, both sexes appear to nose the ground frequently while courting. In six clearly seen cases and apparently in many others, the female first reacted to the spermatophore when her cloaca came in contact with it. In either event the female remained with her cloaca over the spermatophore for several seconds, the longest recorded instance lasting nearly one minute. Usually, however, when a number of individuals were involved, the female would be forced from her position after a short interval. In such instances the female frequently sought contact with another spermatophore. One female thus covered five spermatophores. The taking up of the spermatophore followed most quickly when the female was following the male or moving with the male along the corridors of crevices. One typical record will serve to show how both methods of taking up the spermatophore may occur in the same group. The record was made at the lower pond in Dead Run Swamp, on the Virginia shore of the Potomac, opposite Plummer's Island.

Record of Courtship

"The female first moves away from the spermatophore which the male has produced, although she has been following him for some centimeters. She

later moves back to cover it and shows definite undulations of the base of tail, less intense than the tail wag of the male. A male is now following a female and is rubbing her with his chin. The male wags his tail while following female and rubbing her. The male stops female by throwing tail across her path. The male is now astride female and rubs her with chin. Female slides back and follows male with nose near cloaca. Pair separates. Two spermatophores found on floor. Pair in full waltz. Male crawls over female and rubs her cloaca. Female is now following male. He undulates his tail base and produces a spermatophore. The female misses it and noses about on the ground 5 centimeters from the spermatophore. She finds it and moves first head, then body, and finally cloaca over it. The female undulates her pelvic region. Male still active and turns to female on side of dish. The male thrusts his head under female's cloaca and raises her from floor. Female follows male but no spermatophore is produced. Male now follows female, his tail undulating. A spermatophore is produced but the female turns toward male and the pair waltz. Both undulate their tails. Male plainly seen to produce a spermatophore. The female in waltz position stops, moves away from spermatophore. She turns and moves over spermatophore and secures it while undulating tail base."

Many other records were made in the field, both with glass covered and with exposed salamanders. At Ritchie, Virginia, in a pond where many courtships were recorded, the temperature was 26°–26.5° C. At Dead Run Swamp, Virginia, the temperature ranged from 23.3°–25° C. These temperatures were higher than those maintained in the laboratory.

Many spermatophores were damaged by the adults' walking over them. It was difficult to be sure even under ideal laboratory conditions how much of the spermatophore was taken up by the female with her cloacal lips. Certainly in most cases only the head of the spermatophore was removed by the female. In

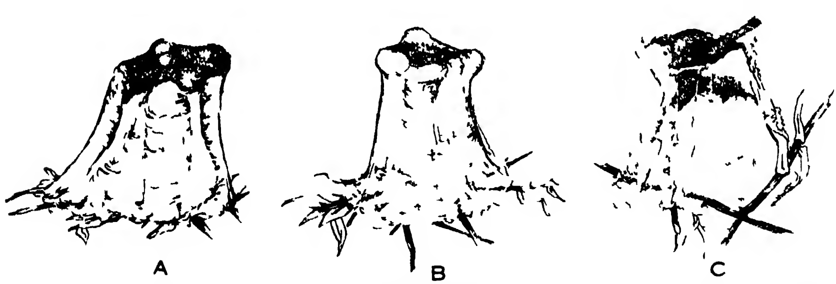

Fig 80 Spermatophores of the marbled salamander, × 4 A Freshly deposited spermatophore B Spermatophore from which most of the head has been rubbed off C Compound spermatophore

Washington, in only five of the fifty or more cases of impregnation observed were the females seen to envelope the entire spermatophore with the cloaca and remove it. In at least twelve the female removed all or part of the head, leaving the stalk still adhering to its place of deposition. Spermatophores usually were deposited on a fairly loose surface of crumbling leaf mold, hence in most cases

the female dragged the stalk from its place of attachment before she succeeded in removing the head. In New York where wet slate was provided, headless spermatophores were frequently found firmly glued to the rock. In the melée of courtship many spermatophores are doubtless crushed and in nature many are presumably covered with dirt or bits of debris, rendering them difficult to see.

The Spermatophore

A typical spermatophore of *A. opacum* is shown in Figure 89. It measures 4 to 5.5 mm. in height and its stalk is approximately 2 mm. wide at the apex and 6 mm. wide at the base. It differs from the spermatophore of *Ambystoma maculatum* in being smaller and in having a quadrangular or pentangular summit. Each corner of the summit is formed by a low rounded prominence and the top of the structure is truncate and slightly concave. In the fresh spermatophore these summits are usually covered with a mass of sperm which are thus placed in a decidedly advantageous position for being engulfed by the cloaca of the female. Lantz (1930, Fig. a) has described a spermatophore which seems to have lost most of this sperm mass. A fresh spermatophore is less concave at its summit than the one he figured, and there is usually a thin cap of white spermatic fluid completely covering the truncate top. The central portion of this surface may be raised into a slight eminence. Sections reveal that this central prominence is formed chiefly of eosinophilic granular substance which agrees in character and staining properties with the secretion of the male's pelvic gland. The spermatozoa are spread over the top of the spermatophore. A remarkable feature is that the heads of the spermatozoa are often all directed the same way. Thus in the micro-photograph (Fig. 90) of the head of one of the spermatophores it may be noticed that the spermatozoa covering one of the four summits are directed outward. This orientation of the spermatozoa would appear to be advantageous to a rapid impregnation.

The base of the spermatophore appears glassy, but slightly frosted, to the unaided eye. Sections reveal that the basophilic mucous material of this base is divided up into short segments by thin partitions of eosinophilic material. Unlike the eosinophilic material on the spermatophore head, this is not granular but homogenous. Sections of the cloaca of the male *A. opacum* reveal that this eosinophilic scaffolding of the stalk is produced by a series of glands lying on either side of the pelvic-gland in the roof of the cloaca. The secretion of these glands is homogenous, in sharp contrast to the secretion of the pelvic glands. Unlike the cloacal glands which line the walls of the cloaca, this secretion is not mucus. With thionin, methylene blue or haematoxylin the secretion of the cloacal glands is stained blue. The abdominal glands, which empty on the cloacal lips distal to the cloacal glands, produce an eosinophilic secretion which is finely granular and hence readily distinguished from both the pelvic gland and from the gland which produces the eosinophilic scaffolding of the stalk.

The abdominal gland may pour its secretion directly to the outside when the cloaca is turgid. It has been assumed that in aquatic salamanders which drive a current of water towards the female during courtship, the abdominal gland secretion is carried in this current and tends to stimulate her. It seemed

to us possible that it was the secretion of the abdominal gland which chiefly interested the female during the "waltz" phase of the courtship. The question arose as to whether or not the spermatophores on being produced become covered with a layer of abdominal gland secretion which would serve to make them, like the male cloaca, attractive to the female. We have shown above that the spermatophore is found by the female even when not in line with her body.

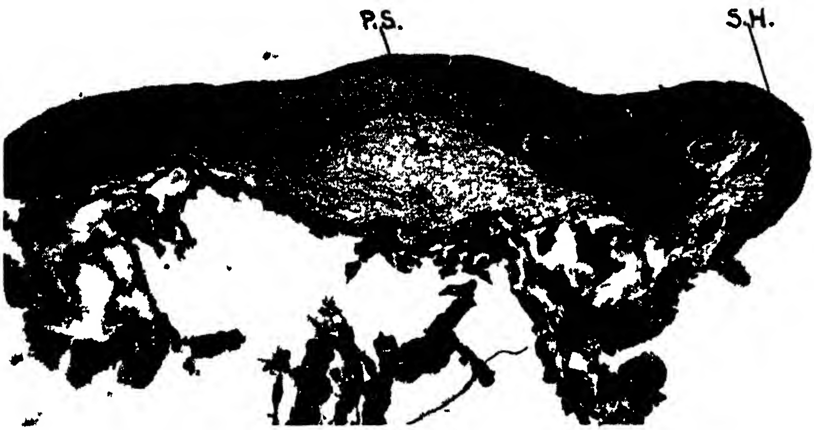

Fig. 90. Vertical section of the spermatophore head of the marbled salamander, × 61. P. S. Pelvic gland secretion. S. H. Mass of sperm heads.

Our sections of the spermatophore fail to reveal evidence of a covering layer of abdominal gland secretion. Moreover, in our sections of the cloaca of the male the secretion of the pelvic, scaffolding, and cloacal glands may be seen in the lumen of the cloaca, but no abdominal gland secretion is found there. If the abdominal gland plays any part in spermatophore formation it produces at most a very superficial covering.

Lastly, it may be pointed out that *A. opacum*, like other species of *Ambystoma*, exhibits some variation in the form of the spermatophore. The groove which is found on one side of the typical spermatophore is frequently lacking. Again, double spermatophores (Fig. 89C) may be produced. Smith (1910) has described compound spermatophores in *A. maculatum*. We have not found a compound spermatophore formed of more than two spermatophores in *A. opacum*.

Method of Sex Recognition

From the above description it may be concluded that there is no recognition of sex at the beginning of courtship but that males endeavor to stimulate any salamander of their own species they chance to meet.

In *Ambystoma maculatum* the males engage in a Liebesspiel with other males and attempt to push under them. Wright and Allen (1909, p. 690) described the action of a male toward a female:

"It seemed to be the object of the male to bring the top of his head in contact with the venter of the female. The throat region of the female seemed to be preferred, although he often began in the cloacal region or even at the tip of the tail and rubbed the dorso-lateral part of the head along her whole ventral side." During the Liebesspiel of *A. maculatum* it has been noticed that the males respond in exactly the same way to other males (Noble 1927, p. 34). Wright and Allen found that the mere presence of females in jars with the males stimulated the latter to the production of spermatophores. We have noted in *A. opacum* that spermatophores are deposited more often after a male has been rubbing a female than at any other time. Spermatophores usually were not produced at the moment the male was nosing the female's cloaca, and it seems probable that secretions from the general integument as well as from the cloaca may excite the males. It may be concluded that in both *A. maculatum* and *A. opacum* the males become sexually active sooner than the females. They excite the colony to sexual activity by engaging in a series of rubbing movements which are exactly the same whether directed toward male or female. Eventually the odor of the female excites the male to the production of a spermatophore. The antics of the male induce the female to follow him and this may automatically lead to the picking up of the spermatophore. However, our work has also disclosed that the female shows a definite interest in the spermatophore and when her body is not in line with it she will move toward it for the purpose of covering it. At the height of the courtship the female appears to be interested in bringing her snout close to the cloaca of the male. The orifice of his cloaca is provided with a series of abdominal glands which are believed to produce a secretion stimulating to the female. It has been suggested above that the abdominal glands may coat the spermatophore with a secretion which makes it attractive to the female. We could find no histological evidence in support of this assumption. Hence it is possible that the other secretions which enter into the formation of the spermatophore are odorous and attractive to the courting female. In brief, our observations suggest that secretions of the integument and cloaca play an important role in sex recognition and stimulation. In this *A. opacum* agrees with the other species of *Ambystoma*.

Comparison with Other Salamanders

As indicated above, the courtship of *A. opacum* agrees essentially with that of *A. maculatum* even though the first proceeds on land and the second in the water. This is further evidence in support of the thesis (Noble 1931) that the courtship pattern is relatively stable in evolution. However, the only other species of *Ambystoma* whose courtship is known in detail, differs markedly from *A. opacum* both in the ability of the males to distinguish sex and in the courtship pattern. Until recently there has been some uncertainty as to the courtship of this species, *A. jeffersonianum*, because the original describer reported the males to embrace "exactly in the manner of the spotted newt" (Wright 1908), and

subsequent observations (Mohr 1931) showed that the male gripped with his forelimbs and usually not with his hind. The observations of Mohr have been confirmed and extended by Kumpf and Yeaton (1932) and one of us has been able to witness the performance several times. Kumpf and Yeaton recorded the courtship of two male and three female *A. jeffersonianum*. There is no doubt that, although these males gripped one another at times, they could distinguish the opposite sex far more rapidly than any courting specimens of *A. opacum* which we observed. The courtship pattern resembled that of *Triturus pyrrhogaster* or *T. torosus* far more closely than it did that of *A. maculatum* or of *A. opacum*. Mohr (1931) concludes "that there is no marked difference in the courtship behavior of *A. maculatum* and *A. jeffersonianum*." The evidence he has so far presented in favor of this is brief. He states that a single male "was seen to be vigorously undulating his tail and whole posterior part of his body. Several times he clutched convulsively at the ground with his hind legs. A female approached, nosing the cloacal region of the male, which almost immediately deposited a spermatophore. The male crawled very slowly away, undulating his tail feebly. The female followed and came to rest with the cloaca immediately above the spermatophore and remained motionless for perhaps fifteen seconds, then pushed vigorously after the male into deeper water."

A second male in the laboratory "swam over a female, grasping her with the forelegs, then slid slowly backward and forward rubbing his cloacal region over the dorsal pelvic region of the female."

At the present time we have no evidence that the male of *A. jeffersonianum* attempts to pry under and lift up the female during courtship, nor is there evidence of a Liebesspiel engaged in by males alone before the females have become stimulated. There are various rubbing movements, but apparently these are not specific for *Ambystoma*. On the other hand the forelimb amplexus is a new phase in *Ambystoma* courtship, a phase which is further developed in another group of salamanders. It has been suggested (Noble 1931) that the courtship of *Ambystoma* is sufficiently generalized to form the ground plan out of which the courtships of the higher groups of urodeles may be evolved. The observations of Mohr and of Kumpf and Yeaton lend support to this view. Their work has also shown that there has been an extraordinary evolution of the pattern of courtship within the genus *Ambystoma*. Further, one species has developed a courtship pattern which is essentially the same as that of certain primitive salamandrids. Since two species of *Ambystoma* have a simpler type of courtship in the sense that sex discrimination is made less rapidly it would follow that the courtship pattern of *A. jeffersonianum* has evolved out of that of these two species. *Triturus torosus* and *T. pyrrhogaster* are not close relatives of *A. jeffersonianum*. Hence the courtship pattern of *A. jeffersonianum* would appear to represent a case of parallel evolution. Many cases of the development of the same structural modification in unrelated groups have been described (Noble 1931). The evidence at hand appears to indicate that the courtship of *A. jeffersonianum* represents a parallelism rather than a case of true genetic affinity.

It may be noted, however, that *A. jeffersonianum* agrees with *A. opacum* in the smaller number of spermatophores produced. This is correlated with the fact that in neither species do the males congregate in great numbers and engage

in a Liebesspiel of several hundred individuals. Our field observations indicate that such large assemblages are characteristic of *A. maculatum.* Because of the irregularities of the terrain these mass formations could not be carried on with any success in *A. opacum.* Possibly the smaller number of courting *A. jeffersonianum* is correlated with the rarity of the species in any one locality. However, Mohr (1930) has recorded 200 specimens of this species in one locality. He states (p. 53): "Everywhere, within three or four feet of the shore Jefferson's salamanders were rising to the top, taking a bubble of air after the fashion of the spotted salamander. Close to shore the salamanders seemed to be congregating." This description agrees closely with our observations of the Liebesspiel of *A. maculatum.* Mohr remarks that the spermatophores of *A. jeffersonianum* are less conspicuous than those of *A. maculatum.* Possibly this is the reason they are not found in large numbers.

In both *A. opacum* and *A. jeffersonianum* there is a smaller mass of spermatozoa in each spermatophore than occurs in *A. maculatum.* This would appear to be correlated with the fact that both species produce on the average fewer eggs than does *A. maculatum.* The spermatophore of *Triturus viridescens* has a very small head of sperm and this species, like *A. opacum,* may lay only half as many eggs as *A. maculatum.* However, to judge from Smith's summary (1911), the difference between the average egg number in the species of *Ambystoma* is not as great as the difference in sperm head sizes. Until a study is made of the number of spermatozoa in the sperm heads of these spermatophores, it will be impossible to state how close is the correlation between egg number and spermatozoa number in the various species of *Ambystoma.*

THE SPERMATOZOÖN

Lantz (1930) appears to have been the first to describe the spermatozoon of *A. opacum.* He states (p. 323):

"At high magnification the sperm looked a tangled mass of spermatozoa intermingled with numerous other much longer and slightly thinner filaments. The spermatozoa are about 75 μ long, thread-like, extremely thin and bear a narrow pointed head piece about 6 μ long. At the time the observation took place they were all perfectly inert, and curved into semicircular shape."

We have examined sections of spermatophores fixed in Zenker's fluid (bichromate of potassium and corrosive sublimate) and have also examined smear preparations of spermatophore heads fixed in Bouin's and in Zenker's solution. We have also examined teased preparations of the fresh spermatophore head. The latter proved much less satisfactory than the fixed material. Delafield's haematoxylin and eosin were used for stains.

The spermatozoa of *A. opacum* are very different from the structures Lantz (1930) has described and figured. They closely resemble the spermatozoa of *Ambystoma mexicanum* as figured by Retzius (1906). The tail is provided with an undulatory membrane extending the entire length except for the tip, which is provided with a lash or end piece. Opposite the membrane a flat keel (Fig. 91) extends for approximately one-sixth of the length of the tail. A similar but apparently shorter keel occurs in *A. mexicanum* and readily distinguishes the

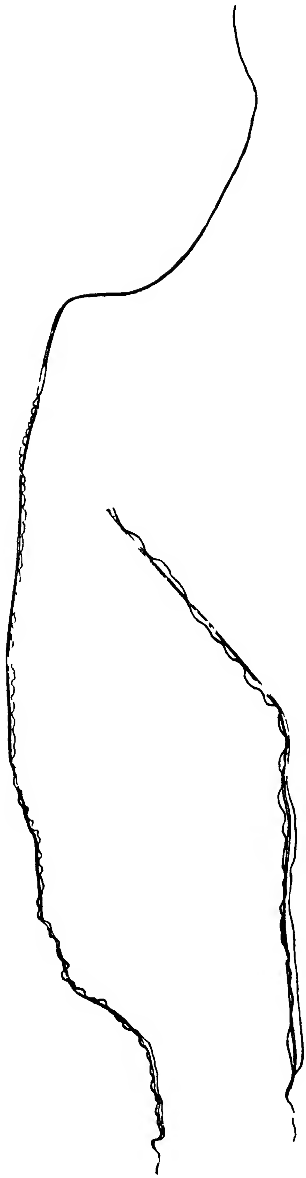

Fig. 91. Spermatozoön of *Ambystoma opacum* A. The whole spermatozoon viewed laterally. B. The caudal portion, under higher magnification showing the forward extension of the keel.

spermatozoön from that of the plethodontids so far as is known (Noble and Weber 1929).

The spermatozoa of *A. opacum* differ from those of *A. mexicanum* as figured by Retzius (1906) in their shorter lash on the tail, the longer head without a barb, and in the less protruding centriole of the middle piece. Under oil immersion the head of the spermatozoön is found to taper to a very fine point. In some preparations the delicate point, or acrosome, may be bent over, but we have failed to find a distinct barb present. This is the more surprising in that the barb is found on the acrosome of many other species of salamanders (Wilson 1925). In our stained preparations the middle piece has a very distinctive appearance. Its anterior fifth or at least the margins of this region take a deep blue stain in striking contrast to the remainder of the middle piece, which stains a bright pink. The spermatozoa vary somewhat in length. Well-fixed spermatozoa are more than six times as long as the structures Lantz described. We have failed to find the "numerous other much longer and slightly thinner filaments" unless these be represented by the sperm heads which, to judge from Lantz's figure, he apparently did not see. Spermatozoa in our smear preparations vary from 480 μ to 530 μ in total length. The parts of a typical spermatozoön measure as follows: head 150 μ, middle piece 10.2 μ, tail exclusive of lash 320 μ, lash or end piece 7.5 μ.

The Egg

There is a general agreement among the various writers as to the number of eggs laid by *A. opacum*. Mann (1855) reported 108 eggs; McAtee (1907) 50 to more than 150; Dunn (1917) over 100; Bishop (1924) two sets of 102 and 73 eggs; Lantz (1930) 94 the first year, 103 the next, for his laboratory specimen. Fifteen clutches taken at Oakwood, all of which we are reasonably certain are single sets, give the following figures: 75, 81, 101, 122, 125, 132, 139, 143, 147, 167, 173, 191, 193, 226, 232, resulting in an average of approximately 150 for the typical sets. We found one set at Oakwood which contained 340 eggs. Since this nest was guarded by but one female and was somewhat off from the main nesting area, it may have been a single set. This number is so large, however, that we do not include it in our average. In a great number of cases in the principal nesting area, as has been stated above, it was not possible to tell where one set began and another ended. In addition to the close proximity of the nesting depressions, as a factor in bringing this situation about, the females apparently move along the tunnels during oviposition, which results in the stringing out of many clutches. A number of eggs apparently had rolled away from the main portion of the sets, for eggs would be found scattered singly or in little groups at various points along the principal nesting tunnels.

Measurements of the eggs with their capsules in the field ranged from 2 to 5 mm. according to the degree of moisture to which they had been exposed. It was subsequently determined in the laboratory that the egg was capable of desiccation to a point where it measured approximately 1.5 mm. without injurious effect. Two batches of 50 eggs each, in this condition when found in the field, weighed 7.2 gms. and 6.68 gms. After twelve hours immersal in water they had gained 5.2 gms. and 6.84 gms. respectively. In another twelve hours

they had gained 2.2 and 1.48 gms., making their final weight 14.6 and 15 gms. respectively. After this there was no further increase in weight. One Oakwood clutch of 125 eggs was divided into five equal portions which weighed, separately: 3.2, 2.75, 4.5, 3.4, 3.92 grams. After twenty-four hours in water their respective weights were 7.2, 6.5, 7.38, 6.5, 6.75 grams. A clutch of 154 eggs from Rock Creek Park weighed 21 grams as taken from the nest. In twenty-four hours immersion it increased 17.75 grams in weight. Another twenty-four hours in the water increased its weight 1.5 grams. From this it will be seen that the eggs, in their normal condition as found in the nest, are capable of absorbing approximately their own weight in water, during the first twenty-four hours immersion. After that period the rate of absorption drops to a negligible point.

Although the eggs are normally deposited separately, we encountered several instances in which a cluster of several eggs were stuck together, adhering to each other by their sticky outer coverings. We also recorded several instances of two eggs' being connected by a well-developed pedestal. In two instances two eggs were enclosed in a common envelop.

The egg of *A. opacum* has been described as being enclosed by two envelops, an outer and an inner, separated by a jelly-like layer (Bishop 1924). Lantz (1930, p. 323) states:

"The egg is spherical, 4 to 5 mm. in diameter and possesses two membranous envelops, separated by a coat of jelly. A much less viscous medium surrounds the vitelline sphere, which measures 2.5 mm. in diameter."

The egg of *A. opacum* preserved in formol appears to have four capsules: a clear wrinkled outer capsule, a grayer and thicker capsule immediately within this, a clearer capsule of the same or slightly greater thickness coming next in order, and finally a thin but highly refractive capsule forming the innermost of the series. Between the inner capsule and the egg with its closely adherent vitelline membrane is a large water space. The vitelline membrane, often difficult to see in living eggs, is clearly visible in these eggs when a cleavage furrow is viewed from the side. A typical egg measures 2.8 mm. in diameter. The greatest diameter of the water space is 4 mm. The diameter of the surrounding envelops, reading from within out, is as follows: 4.1, 4.5, 4.8 and 5 mm.

In the fresh eggs these same capsules may be recognized readily even in those four months old and ready to hatch. The outer capsule is thin and soft. Dirt and other debris adhere to it. Within this is the thicker and resistant second capsule. When this is cut through, the embryo, enclosed in the highly refractive inner capsule and the one surrounding that, slips readily through the puncture. It is then seen that the capsule third from the outside is very soft and gelatinous as Bishop and Lantz state. We prefer to call this a capsule rather than a jelly layer since it has the structure of a capsule in eggs preserved in formol. In living eggs it differs from a capsule in that it forms an amorphous mass when pulled free from the other capsules. In fresh eggs ready to hatch the water space surrounding the vitelline membrane is eliminated by the pressure of the large embryo. In brief, we recognize the same structures Lantz described in the egg of *opacum* but we call his "coat of jelly" an egg capsule and we recognize an additional outer capsule formed of soft adhesive material.

THE BROODING HABIT

Much has been said of the attitude of the female *A. opacum* toward her eggs. It is generally agreed that an adult is usually associated with the egg mass and the guardian upon examination has been found to be a female. In 1929, we collected eighty-one females guarding their eggs. Only one male was taken in the nesting area. It was found near a female with three freshly laid eggs in a very indistinctly formed depression under a brush pile. This case may indicate that, in nature, oviposition closely follows impregnation. Lantz (1930) found that oviposition did not occur until two weeks after fecundation in his laboratory specimens. We have seen spermatophores produced the same night that eggs were laid in the laboratory (September 28). Only one female was found outside the principal nesting area at Oakwood during 1929. This was a spent animal and was not associated with any eggs although it is possible that her nest had been overlooked. In some instances it was not possible to identify the respective broods of adjacent females, the clutches being so confluent that we were unable to separate them. In several instances nests were found unattended, in both the Oakwood and Rock Creek sites, and at another point nearer Oakwood. It is quite possible that the disturbed females in these cases made off before discovery. As will be pointed out below, the female will usually desert the eggs upon being disturbed.

Mann (1855) describes the female as being found "curled up" on top of the eggs. Dunn (1917) reports the mother as "lying on top of them." Lantz (1930) writes the "female sits on the eggs." In our experience the female was usually found on the periphery of the egg mass, the tail either turned toward and encircling some of the eggs or turned away from them. The clutch itself was invariably too large and too well spread out to permit the female to come into contact with more than a small portion of it at a time. When completely exposed the female usually pushes her snout into the egg mass, a reaction apparently due to negative heliotropism. Often, when a convenient means of escape is at hand, the female departs with celerity.

In the plethodontid salamanders the female will return to her eggs, apparently being attracted by them. Wilder (1917) found that a female *Desmognathus fuscus* will brood the eggs of another female. We have performed some experiments both in the field and in the laboratory to determine how close is the bond between the female *A. opacum* and her eggs. In the field brooding females were marked for identification by ligatures attached to the limbs. Then these females were transferred into one another's nests. In one instance, one of the females remained in the strange nest into which she was placed the day before, while the rightful owner of the nest disappeared from the strange nest into which she had been placed. Marked specimens were removed to distances of from twenty-five centimeters to one meter from their nests. The nests were carefully covered but the next day no female was found to have returned to her nest. In the case of two adjacent nests found unattended the first day, a female was found to have appeared and come into contact with one of the groups of eggs the next day.

In the laboratory a crystallizing dish was filled with clay sub-soil from the

nesting area. Inter-connecting depressions, six in all, corresponding to those in which the nests were found, were made in the clay. A clutch of eggs was placed in one of these depressions. The whole was then covered with a layer of moss and leaf mold, to correspond to the conditions in the nesting area. The female found with this clutch was then placed in the dish. Although she stayed in the depressions during a period of twenty-seven days, she moved from one to another without evincing any preference for the one containing her eggs, but showed a disposition to remain for some time in any one depression.

Four nests were placed in soil and débris in a large tank. The nests were then covered with a layer of moss. The four females to whom these nests belonged, having been marked for identification, were placed in the tank. During a period of two weeks they remained in depressions other than those containing the nests. It was again noted that the animals, once located, showed little disposition to move.

Ten nests were placed in crystallizing dishes. The clutches were placed in the centers of the dishes, surrounded by layers of moss and débris. During a period of thirty days no marked tendency to remain with the egg mass was observed in the female. Depressions in the moss seemed to be as satisfactory as the egg mass for the female. The coiled attitude, observed in females associated with their eggs, may also be assumed by the animals when occupying positions removed from the eggs.

From these experiments it would seem that the eggs lack any great attraction for the female *A. opacum* and that definite orientation toward the eggs, such as is exemplified by *Desmognathus* (Noble and Evans 1932), is lacking in this ambystomid. In the laboratory while these experiments were being carried on we had a brooding *Desmognathus fuscus* and a *Plethodon cinereus* which would invariably return to their eggs. Under the conditions imposed in the laboratory there was no doubt that the female *A. opacum* was not attracted by her eggs as strongly as the terrestrial plethodontids mentioned were attracted by theirs.

It seemed to us possible that the disturbance caused by transporting the salamanders might have prevented the normal appearance of a brooding instinct in the laboratory. Therefore, we decided to secure further data on the duration of the brooding period under natural conditions. In the Washington area during 1931 we secured the following data:

In Rock Creek Park on October 12 most nests in the upper part of pond, where it was damp, were found to be deserted. In the lower pond area, where it was drier, some females were found with eggs. Four nests with females were located under a large log pile. One could view these without disturbing them by moving the top log. The temperature on this day was 10° C. There was only a trace of water in the pond but the ground was damp. On October 14, with the temperature at 17.5° C., a slight drizzle falling and making the ground wet, only two of the females were present. We shall call these No. 1 and No. 4; the missing two, No. 2 and No. 3. On October 15, with the temperature at 17.8° C., the rain falling and the ground very wet, all females were guarding their nests except No. 2. On October 16, with the temperature 11.5° C., the rain falling and the ground under the logs wet, females No. 3 and 4 were present but the others were not seen. On October 17, with the temperature at 10° C. and the

ground saturated, all females had left their nests. On October 21, although the ground was dry and the temperature up to 11.2° C., the nests were still deserted. Hatching was in full sway on November 21 when the ground was again very wet. It had been raining hard during the week. On November 22, only eight unhatched eggs were left in nest No. 1, only fifteen in nest No. 2 and forty-three in No. 3.

We made less extensive observations in other localities. For example at a pond on the Glover estate, Georgetown, D. C., on October 4, the temperature was 24° C., and the ground was very dry. Out of fifteen nests seen in one locality and seven in another, only two lacked an attending female. These observations agree with those made during 1929. During early October when the ground is dry the nests are usually attended by the maternal parent.

In Dead Run Swamp on October 11, the temperature was 16° C. and the ground was damp because of extensive rains during the previous week. Most of the nests found were deserted and contained swollen eggs. Only three females were found with eggs near one pond and only one nest with brooding parent near the other pond. Three nests were selected for further observation. No. 1 contained 150 eggs, No. 2 had 225 and No. 3 held 170 eggs. Larvæ could be seen within the egg capsules and a trace of a balancer was observed in specimens examined. This locality was not visited again until October 18. Then the temperature averaged 10° C. No females could be found near their nests. All eggs were found to be greatly swollen. The larvæ examined had absorbed their balancers and some had hatched. In set No. 1 about seven eggs had hatched, in set No. 2 about three. Only nest No. 3, which was on drier ground, had no hatched eggs.

It was very interesting to find that certain salamanders had been feeding on the eggs. Two *Desmognathus fuscus* and no less than five *Eurycea bislineata* were caught very near the eggs. The *Desmognathus* stomachs contained *opacum* eggs and larvæ. Three capsules were taken from the first *Desmognathus* and four capsules and partly digested *opacum* larvæ from the second. Several predacious beetles also were seen with the eggs. This observation indicates that if the female leaves her charge before hatching, the eggs may be devoured by *Desmognathus* and apparently by other enemies.

This conclusion was confirmed by later observation. On November 1, further examination of these nests in Dead Run Swamp was made, when the ground was dry and the temperature was 7.2° C. All three sets of eggs were reduced. Nest No. 1 contained one hundred eggs, No. 2 held only ninety, and No. 3 contained one hundred and twenty eggs. Again Amphibia were captured with *A. opacum* eggs in their stomachs. One *Eurycea bislineata*, two *Desmognathus fuscus* and one *Rana clamitans* were found to have eaten the *opacum* eggs. Many beetles were found in the nests. It does not follow that these amphibian enemies had been attracted to the eggs by smell alone. In the laboratory we have seen a *Desmognathus* snap at an *opacum* larva moving within its egg capsules. On November 15, the egg number was reduced to seventy-five in nest No. 1, fifty-eight in No. 2 and ninety-three in No. 3. Some insects, but no Amphibia, were found in the nests. On November 1 and November 15 a search was made for hatched larvæ in the nests, but none was found.

Unfortunately no opportunity permitted our following the fate of eggs in other localities. These Washington observations indicate:

1.—The female parent leaves her brood about the end of the first month, and apparently after heavy rains.
2.—Before deserting her eggs, the female may move about. Our observations show that she does not guard her eggs continuously.
3.—In the field, as in the laboratory, many eggs hatch on land when the ground is saturated. Probably crevices or crayfish burrows may hold sufficient moisture to permit the survival of these larvæ, which are structurally fitted for life only in water.
4.—When the female leaves, the eggs may be eaten by salamanders, insects or other enemies.
5.—These enemies as well as droughts, considered in another section, play an important role in keeping the species in check.

Lantz (1930) reports that his female *A. opacum* in the laboratory remained with the eggs steadily at first and intermittently later on. We found females in the field brooding their eggs in the daytime and at night. Our field observations indicate that the female may return to the eggs once she has left them. We secured evidence, however, that the females do not forage for food, at least not during the early part of their brooding. We examined the contents of the stomachs of twenty-six brooding females taken in the Washington region in October 1929. Of these nine were empty, and fourteen contained nothing but bits of shed skin and vegetable débris, which, no doubt, had become entangled in the skin at the time of swallowing. The other three contained, besides the cast skin and vegetable matter, (1) an ant and another small hymenopteran, (2) a coleopterous larva, (3) an egg, apparently in early cleavage stages. It seems reasonable to believe that the last item was accidently swallowed and that *A. opacum* brooding females do not feed on their eggs as does the male *Cryptobranchus.*

Lantz (1930, p. 324) remarks in regard to *A. opacum:* "In the natural habitat of this species the eggs are laid in the vicinity of ponds, and the female has been observed to move them to higher grounds when the ponds rose." Our observations in the field lend no support to this assumption. In the Oakwood nesting area we placed a female and her eggs in a mud basin, in a tiny spring pool at the lowest point of the pond bottom. This basin was so arranged that the water partly covered the clutch, but some of the eggs were in contact with the surface. The female was placed on top of the eggs. The next morning she had deserted the nest in the improvised basin. In the Rock Creek station, however, a nest was found partially submerged, the egg capsules being just in contact with the water's surface. The female in this case was sitting on top of the eggs. As we have stated above we have not found this to be the normal position. This nesting site, customarily dry at this time of year, had been flooded by heavy rains which had occurred during the previous week. The instance would indicate that the female does not leave the eggs until full submergence occurs unless she is disturbed. However, as reported above, we have seen other cases of the female's leaving before this time. In most of the nests

we observed there were no lower and upper levels available to which the female could move the eggs and this, coupled with the fact that there would be obvious difficulties in the way of a salamander's moving a batch of one hundred or more separate eggs, makes it seem hardly possible that such behavior ever occurs. The female may play some part in keeping the eggs moist, however. The bladders of all brooding females were found to be greatly distended with fluid and it is quite possible that this factor would be of service in moistening the eggs, as has been suggested in the case of *Aneides lugubris* (Storer 1925). However, the brooding female may have other duties; we never found her nest attacked by the Amphibia or by insects while she was present. Her presence, therefore, may be of some advantage to the eggs.

Development

It is usually assumed from the work of Dunn (1917) and others that the eggs of *A. opacum* can withstand long periods of desiccation and that they do not hatch until covered by the rising waters of the ponds near which they are laid. Lantz (1930, p. 324) has reported some observations which are at variance with this view. He states:

"Considerable latitude exists with regard to the time of hatching and the larvæ will remain alive inside the egg for a very long time if for some reason hatching is delayed. In one egg kept on land the embryo lived 207 days; another which had been immersed in water the day after it had been laid, remained alive four days longer than the previous."

In order to secure more data on the relation of water to growth and to hatching in *A. opacum* we have repeated the experiments of Dunn and of Lantz on large series of eggs. We selected a number of clutches and divided each clutch into three approximately equal parts. One group (a) was placed in water 4 to 5 cm. in depth. A second series (b) was placed on saturated sand while a third series (c) was arranged on dry packed sand in chambers. Covered crystallizing dishes of the same diameter were used for containers in each case. The results of these experiments may be briefly listed:

Experiment 1a.

Forty-two eggs swollen with moisture in the field, placed in water on November 4. In ten days' time 92.5 per cent had hatched, as follows:

November	5	6	7	8	9	10	12	13
Number hatched	7	10	1	3	4	1	6	5

The balancers were large in the larvæ first hatched and reduced in the last. There was little change in the limbs. The first larvæ hatched were 16 mm. in total length, the last 17 mm.

Experiment 2a.

Twenty-five eggs, less swollen than those of Exp. 1a, were placed in water on November 4. In fifteen days 76 per cent had hatched.

November	4	5	6	7	8	10	11	14	19
Number hatched	2	1	7	1	3	1	1	2	1

The balancers were developed in all the larvæ at hatching, but there was

a decided difference in the limbs. In the first hatched the digits of the fore limb were not differentiated and the rear limb rudiments were not visible. In the last hatched three digits were present on the fore limb and the hind limb rudiment was present.

Experiment 3a.

Fifty-six eggs, found in a desiccated state in the nest, were placed in water on November 5. In forty-one days 88.4 per cent of the eggs had hatched:

November–December	5	6	9	13	17	18	23	1	4	6	7	8	9	11
Number hatched	1	1	2	1	1	2	3	11	1	5	7	4	6	1

The first hatched was only 13 mm. in length. It had large balancers and rudimentary fore limbs. The last hatched had the balancers practically gone and three digits visible on the fore limb.

Experiment 4a.

Sixty-three eggs, swollen with moisture from their damp nests, were placed in water on December 4 and within seven days all had hatched.

December	5	6	7	8	9	10	11
Number hatched	7	2	11	7	9	14	13

The first hatched was 20 mm. in length, the last hatched was only 18 long, and had the fore limb digits in a less differentiated stage than the earlier hatched one of larger size. The balancer of the last was well reduced, giving evidence of its greater age. These two larvæ are represented in figures 92 C and D

Experiment 5a.

Forty-eight eggs, found desiccated in the nest, were placed in water on December 4. In twenty days 75 per cent had hatched:

December	7	8	9	10	11	12	13	19	20	24
Number hatched	1	1	13	7	5	3	3	1	1	1

The first hatched was only 13 mm. long with the fore limbs in the limb bud stage. The lips were barely formed and the balancers were large. The yolk sac was still prominent. The last hatched measured 18.5 mm. in total length Three digits were present on the fore limb, a rudiment of the hind limb had appeared and the balancers were reduced.

Experiment 6a.

Twenty-eight much desiccated eggs were placed in water on December 4. In thirty-two days all had hatched:

December–January	5	7	8	10	11	12	16	21	22	24	27	28	30	31	5
Number hatched	3	1	1	2	7	1	1	1	3	2	1	2	1	1	1

The hatching of these submerged eggs extended over a period of a month. The enormous difference between the first and last hatched is shown in figures 92 A and B. The first hatched measured 10.5 mm. in total length, the last 18.5 mm. In the first, the lips, the eyes and the gills are rudimentary; the fore limb is represented by a bud. A large yolk sac and a not completely developed balancer are present. In the last hatched the balancer has been absorbed and the other larval structures are well developed.

Experiment 7a.

Thirty-four eggs were immersed in water on December 4. These had been partly dried in the field and were small. Over a period of seventy-six days, only 75.38 per cent of the eggs hatched.

December–January–February	10	11	16	22	2	6	7	8	1	4	24
Number hatched	1	2	3	9	4	3	1	1	1	1	1

The first hatched were only 13 mm. in total length and, like the first hatched in the previous experiment, had rudimentary gills and fore limbs. The last hatched was 19.5 mm. long and had four digits on the fore limb, the hind limb rudiment present, and the gills elongate.

In these experiments eggs frequently failed to hatch. Bishop (1924) found small nematodes emerging from the egg capsules of *A. opacum* simultaneously with the larvæ. He points out that while these parasites seemed to have no effect on the hatched larvæ, they may have accounted for the death of some eggs that failed to hatch. No nematodes were noted in our experiments. A dead egg very soon molds, and mold did not grow on most of the eggs until all the larvæ reported above had hatched. This indicates that the death of the larvæ was due to failure to hatch.

Several conclusions may be drawn from these results:

(1) The development of the encapsulated larvæ is correlated with the degree of moisture to which the eggs are exposed during the time they are in the nest. Swollen eggs usually contain well developed larvæ; desiccated eggs hatch out larvæ in a more embryonic condition.

(2) The time required for hatching, after immersion in water, is variable, ranging from seven to seventy-six days for these seven clutches. Again, the eggs which had been swollen with moisture require the least time in which to hatch.

(3) The percentage of eggs which normally hatch from each clutch is variable, ranging in these cases from 75 to 100 per cent and averaging about 86.75 per cent. In the case of those eggs which failed to hatch, there was always a normal development for a certain period.

(4) The larvæ may emerge from the egg in any one of a wide range of developmental stages.

Dunn (1917) reports balancers and fore limbs on his newly hatched larvæ. Bishop's (1924) specimens all lost their balancers before hatching. Lantz (1930) reports balancers present on his larvæ at hatching, also digits on the fore limb and a rudiment of the hind limb visible. He says, however, that if hatching is retarded the larvæ may emerge from the egg without the balancers and with a rudimentary fourth finger. The total lengths given for hatching specimens [15 mm. (⅝ inch), Deckert, 1916; 19 mm., Brimley, 1920; 15–19.5 mm., Lantz, 1930] do not fully cover the range exhibited by our series. Our specimens at hatching range from very early larval stages in which the eyes were not yet functional, the lips barely formed, the gills still without rami, and the fore limb in a rudimentary bud stage, to advanced stages in which the balancers had entirely disappeared, the four digits of the fore limb had become differentiated,

the rear limb bud had appeared and the larva had assumed a mature larval habitus. The escaping larvæ ranged from 10.5 to more than 20 mm. in length

In the experiments comprising series "b," as stated above, the eggs were placed on saturated sand, in moist chambers. The sand was banked at an angle and a small amount of water was kept at the bottom of the slope to in-

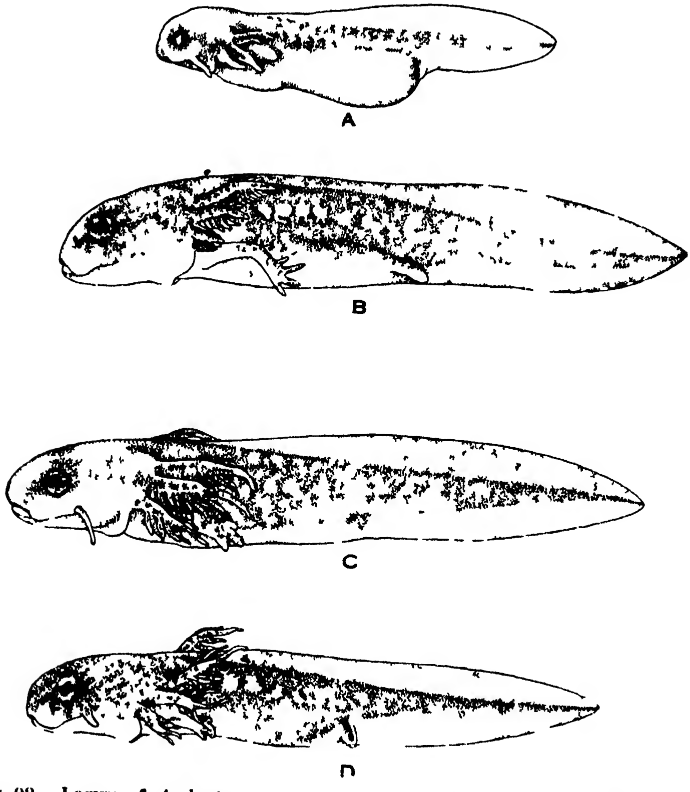

Fig 92 Larvæ of *Ambystoma opacum* at the time of hatching, × 4 2 Balancers rudimentary gills and limb buds may be present, or the balancer may be absorbed and the gills and anterior limbs well developed at this time A and B are larvæ from the same egg mass, the larva shown in B having hatched January 5, 1930, a month later than the larva shown in A C and D are larvæ also from a single egg mass, the second (D) having hatched six days after the first Although the reduced balancers indicate that the last hatched larva is in a more mature stage of development, the larva is not as large as the one hatched nearly a week earlier

sure complete saturation. The eggs, however, were not in contact with the water. In five of the seven dishes some of the eggs hatched, after remaining for some time on this saturated medium. Some of the larvæ made their way into the shallow water at the bottom of the dish. If they were unable to reach the water, as was usually the case, they seldom survived more than a few hours. We briefly summarize the experiments in this "b" series below.

Experiment 1b.

Forty eggs were placed on saturated sand on November 4. The first hatched forty-one days later, the last after fifty-four days, as indicated below.

December	14	17	24	25	26	27
Number hatched	1	2	1	3	1	1

Only 22.5 per cent of the eggs hatched. Some of the remainder lived in good condition until January 28 without hatching. One larva removed from the capsules on January 7 had lost the balancers and was developing the hind limb buds.

Experiment 2b.

Twenty-five eggs were placed on saturated sand on November 4. Only 28 per cent hatched, the first after fifty-two days, the last after one hundred days. Their hatching schedule was as follows:

December	25	28	29	Feb. 2	10	17
Number hatched	1	1	1	1	1	1

Two unhatched eggs were still alive on March 4. The last hatched, unlike the first hatched, had lost the balancers, differentiated four digits on the fore limb and had hind limb buds.

Experiment 3b.

Fifty-five eggs were placed on saturated sand on November 4. Only 10.9 per cent hatched, and these from thirty-three to fifty-four days after the beginning of the experiment.

January	6	12	18	19	23	27
Number hatched	1	1	1	1	1	1

All the larvæ which hatched had lost the balancers and acquired all four digits.

Experiment 4b.

Fifty-nine eggs were placed on saturated sand on December 4. Only 20 per cent hatched and these from twenty-one to thirty-six days later.

December–January	24	26	27	28	30	1	8
Number hatched	1	3	1	4	1	1	1

The first hatched had balancers, three digits on each fore limb, and lacked the rear limbs. The last hatched had lost the balancers, had acquired four digits on each fore limb and had developed hind limb buds.

Experiment 5b.

Forty-eight eggs were placed on saturated sand on December 4. Only 12.33 per cent of the eggs hatched and these from thirty-seven to sixty-nine days later. The hatching record follows:

January–February	9	21	23	27	29	10
Number hatched	1	1	1	1	1	1

One egg lived until March but failed to hatch. All the larvæ in this experiment had lost the balancers before hatching. The fore limbs had four digits.

Experiment 6b.

Twenty-seven eggs were placed on saturated sand on December 4. None of these eggs hatched but one lived until January 12. One removed from the capsules on January 6 had lost the balancers and had differentiated all digits on the fore limb.

Experiment 7b.

Thirty-seven eggs were placed on saturated sand on December 4. None of these hatched but apparently they all lived until February 13. One larva removed from the capsules on January 6 had lost the balancers and developed hind limb buds.

Although all workers who previously had considered the eggs of this species have held that complete immersal in water was requisite for hatching, the results of this experiment show that this is not necessarily the case. Contact with a sufficiently damp medium was enough to hatch more than 13 per cent (13.39) of nearly 300 eggs exposed to it. This percentage would have been higher if we had selected only eggs swollen with moisture in their nests for the experiment (See series "a").

The series "c" experiments demonstrate the ability of the eggs of *Ambystoma opacum* to withstand a great amount of desiccation. It will also be seen, from the results, that intra-capsular development was not always retarded by the dry medium on which the eggs were kept.

Experiment 1c.

Nov. 4: Forty eggs placed on dry, packed sand.

Jan. 4: Sixteen eggs still good. One removed from capsule had balancers and rear limb buds.

Mar. 4: One egg left. On removal from capsule embryo was found still to have balancers, a rudimentary fourth finger and hind limb buds.

Experiment 2c.

Nov. 4: Twenty-five eggs placed on dry packed sand.

Jan. 7: All good. One removed from capsule had balancers and a rudiment of the fourth finger.

Mar. 4: One egg left. On removal from capsule larva was found to have lost the balancers and to possess a developed fourth finger and buds of the hind limbs.

Experiment 3c.

Nov. 4: Fifty-five eggs placed on dry, packed sand

Jan. 4: Eighteen left. One removed from capsule had traces of balancers, fourth finger and hind limbs rudimentary.

Mar. 4: Two left. The larvæ removed had the barest rudiments of balancers. The fourth fingers were rudimentary and the hind limbs still in bud stage.

Experiment 4c.

Dec. 4: Fifty-nine eggs placed on dry, packed sand.

Jan. 6: Nine in good shape. One removed from capsule lacked the bal ancers; had a fourth finger and rear limb buds.

Mar. 4: Desiccation had proceeded too far at this time.

Experiment 5c.

Dec. 4: Forty-seven eggs placed on dry, packed sand.

Jan. 6: Eleven in good condition. Balancers lacking on specimens taken from capsules at this point, four digits on fore limbs, rear limb buds appearing.

Mar. 4: Four remaining eggs recently dead.

Experiment 6c.

Dec. 4: Twenty-six eggs placed on dry, packed sand.

Jan. 6: Sixteen appear viable. One removed from capsule lacked balancers and showed hind limb buds.

Mar. 4: Four alive. Much desiccated. Balancers gone but fourth fingers and rear limbs still comparatively rudimentary.

Experiment 7c.

Dec. 4: Thirty-four eggs placed on dry, packed sand.

Jan. 6: Thirteen good. Example removed from capsule has no balancers but still had yolk sac; fourth finger rudimentary; no hind limb buds.

Mar. 4: Two good. Traces of balancers in one, none in other. Both embryos showed rudimentary fourth fingers and hind limbs.

To summarize, of one hundred and twenty eggs over a month old at the beginning of the experiment, practically 40 per cent were capable of standing a month's rigorous desiccation. Slightly more than 3 per cent survived two more months. More than one-third of one hundred and sixty-six eggs at least two months old survived a month's desiccation. A little more than 3 per cent lasted another two months under the same conditions. We may assume from these results that the eggs are capable of withstanding the several periods of drought which take place in the field. Conditions there would hardly approximate the degree of aridity to which the eggs in this experiment were exposed. Under more normal conditions a much greater percentage of the eggs will last over similar periods of time.

The longest period on record for eggs remaining within the nest is fifty-two days, recorded by Brimley (1920). Bishop (1924) kept the eggs more than a month. Lantz (1930) reports one egg kept on land in the laboratory, in which the enclosed larva lived for two hundred and seven days. We have kept eggs of *opacum* in good condition for over a year in our ice box at temperatures of 7° to 10° C. Lantz (1930, p. 324) comments on his long-term eggs: "If, however, hatching is retarded too long, the larvæ weaken gradually and become incapable of normal development, even if they finally succeed in freeing themselves from their envelopes." In the case of eggs kept seven months in the ice-box at 7° to 9° C., a fair percentage hatched out and developed normally when placed in water, the larvæ being fed *Daphnia* and *Enchytræus*. Our eggs over a year old did not hatch, but the enclosed larvæ were alive.

In view of these findings we have endeavored to determine if *opacum* normally ever winters over in the field. In the Washington area the fall of 1930 and the winter of 1931, were unusually dry. Evidence that some of the eggs survived this drought was obtained during March 1931, when several batches

of viable eggs were found in the still dry breeding ponds. In the Dead Run Swamp area, on the Virginia shore of the Potomac opposite Plummer's Island, two batches containing seven and thirteen eggs were found on March 5. Two days later a batch of fourteen eggs was found in the same locality. All of these eggs contained living larvæ. Most of them hatched immediately upon being placed in water. Some of the eggs in each batch—one in the first, three in the second and three in the third—failed to hatch after remaining immersed in water for several days, although the larvæ were alive when removed from the capsules. Batches of twelve and fourteen eggs were found in Rock Creek Park breeding sites on March 12 and one batch of fourteen was found near Priest's Bridge, Md., March 14. Most of these were viable but, as with the other sets, a few in each batch failed to hatch after immersion, although containing living larvæ. Half of the eggs in the last batch were placed on wet blotting paper, the other half being submerged in 2 cm. of water. Except for the few which failed to hatch, both groups of eggs hatched within the same period of time, one hour. All of the larvæ from these wintering-over eggs were in an advanced stage of development, possessing well developed branchiæ and rear limb buds and having the digits of the fore limbs well developed. They were all in a much weakened condition and extremely thin. They readily responded to efforts to feed them with entomostracans but failed to thrive on a diet of enchytræids. The failure of some of the larvæ to escape the egg capsules is paralleled by our experience in the laboratory and shows that the encapsulated larva may reach such a condition, if hatching be delayed, that the hatching mechanism may become unable to function. The number of eggs in these delayed batches (average twelve) is much below that which we have shown to be average for normal clutches at or near the time of laying. Hatching due to chance wetting caused by rains and thawing, or destruction by enemies, or both factors, probably account for this reduction in number. Although no empty egg capsules were found with these eggs, decay over the long period of time or extreme desiccation may have accounted for their disappearance. Observations made during the fall of 1931 in the Washington area indicate that amphibian and insect enemies destroy a high percentage of the eggs. These observations are discussed above.

In the present paper we are not describing either the early development of the egg or the later larvæ secured from the ponds. Such descriptions to be of value should point out the resemblance and differences between these stages in the life cycle of *opacum* and similar stages in other species of *Ambystoma*. At the time of writing we do not have adequate comparative material at hand. Mr. J. A. Weber has secured metamorphosing *opacum* at Miller's Place, July 4, 1929, and we have many records for *opacum* larvæ from Long Island ponds during the spring months.

The purpose of this paper has been to report in detail our observations on some of the more distinctive features in the life history of *A. opacum*. The most unusual feature of this life history is the habit of laying on land eggs which are destined to produce aquatic larvæ. It may be of interest to inquire further into the probable significance of this habit in the economy of the species.

Dunn (1917) has suggested that this terrestrial stage in the life cycle may represent an adaptation to the Atlantic coastal plain, with its conditions of

flood and drought. It does not seem to us that the distribution of the species lends support to this view. The species occurs throughout most of the Piedmont plateau and is found in the New England upland and in various areas in the interior lowlands. Its requirement of a semipermanent pond, which must contain water during at least the winter and spring months, is better fulfilled by the irregular topography and extensive drainage systems of such a region as the Piedmont plateau. In the coastal plain, with its relatively much more porous top soil and its greater rate of evaporation, these ideal conditions are less likely to be found. One of us has recently collected *opacum* in some numbers at Biloxi, Mississippi. The species was found thirty miles from the coast in hardwood swamps. According to Allen (1932) this species does not occur at all on the sandy coastal plains skirting the gulf coast at Biloxi. Here *Ambystoma talpoideum* breeds in small pools. This species which flourishes in a sandy coastal plain has not given up the water breeding habits of *A. maculatum.*

Those who have had field experience with species of *Ambystoma* have often found that different species occurring in the same area breed either in different though perhaps adjacent ponds, or if in the same pond, at different periods. Smith (1911) pointed out that, in the vicinity of Ann Arbor, *A. maculatum* and *A. tigrinum* breed in different ponds, "each species occurring to the exclusion of the other." He noted only a single exception to this rule. We have found the rule to hold for the Syosset area of Long Island. Piersol (1929) shows that *A. jeffersonianum* breeds before *A. maculatum,* in the pools around Toronto. The larvæ of the *A. jeffersonianum* are well developed by the time those of *A. maculatum* hatch, and feed largely upon them. This condition is balanced by the factor of pathologic polyspermy in a large proportion of the eggs of *A. jeffersonianum* induced by the low temperature of the water in which they are laid. The irregular development which follows destroys many of the eggs of *A. jeffersonianum.* Since this species is known to be an earlier breeder than *A. maculatum* throughout the common range of the two species, the temperature factor would appear to keep the more voracious *A. jeffersonianum* in check. Throughout much of its range *A. opacum* occurs in the same area with *A. maculatum.* The latter species produces more eggs than the former. Wherever the forms occur together as near Coram, Long Island, and in the Washington stations, they may breed in the same ponds. It may well be that after the perils of the several preceding months, the well-developed larvæ of *A. opacum* are so greatly reduced in numbers that *A. maculatum* is able to continue successfully. Such factors as active enemies in the more southern portion of the range, extreme cold with resultant ice in the northern parts of the range, together with periods of too prolonged drought throughout the range, must reduce greatly the number of *opacum* larvæ which live to transform. Since both species are so exceedingly abundant in the same area one would look for some such balance, as the larval habits appear to be the same. The adults of the species range over a large area but the number of available breeding sites within the area is comparatively small and would result in much concentration were the spawning dates to occur simultaneously. Therefore, we look upon the fall breeding and terrestrial egg-laying habits of *opacum* as an adaptation to avoid competition with other species of *Ambystoma.*

Mechanism of Hatching

Previous to the publication of our preliminary note (Noble and Brady 1931) on the hatching mechanism in *A. opacum* it was generally assumed that the larvæ escaped from the egg capsules by mechanical means. Bishop (1924) states "the embryo breaks out" of the capsules. Brimley (1920) mentions the larvæ as "trying to hatch out" before the eggs were placed in water. Lantz (1930) assumes that the egg capsules are weakened by the water. He states:

"With regard to the mechanism of hatching itself, it seems probable that a large part is played by sudden swelling of the eggs through rapid absorption of water up to the bursting point of the membranes. Eggs immersed in water in the earliest stages will develop normally, but the larvæ seem incapable of hatching or they do so very late, when obvious disintegration of the membranes has taken place."

Since larvæ may hatch either head or tail first it appeared highly probable that the capsules had given way at their weakest point to the pressure exerted by the half-coiled embryo within. However, in the experiments reported above we found that in many clutches of eggs immersed in water some of the eggs will fail to hatch even though they contain living embryos. It seemed strange that in eggs developing side by side all should not hatch at approximately the same time if the only factor concerned was that of water absorption with an accompanying disintegrating effect upon the capsules. Further, as stated above, we observed many instances of eggs hatching on damp sand. These observations forced us to reject the conclusion reached by Lantz that:

"The conditions required for normal hatching seem to be for the eggs to remain on land in moderately humid surroundings until mature, and then to be suddenly immersed in water."

The eggs obviously could hatch under other conditions, and moreover many eggs did not hatch when placed in the conditions which Lantz indicated. This caused us to search for another mechanism of hatching. One of us had previously shown that in *Alytes*, the Midwife Toad, the eggs could also be induced to hatch on land. In this species the larvæ were freed from the egg capsules apparently by the digestive action of a series of unicellular glands scattered over the snout (Noble 1926). These hatching glands had been previously described in an aquatic frog, but were unknown in any urodele until Wintrebert (1928) reported them in *Ambystoma mexicanum*. Sections of the larval *A. opacum* just before hatching reveal large numbers of these unicellular glands present over the snout and extend along the sides and top of the head. None are present on the tail.

The hatching glands are large epidermal cells which stain intensely with plasma dyes (Fig. 93). In Mallory's anilin blue connective tissue stain, following fixation in Zenker's solution, the hatching glands stain yellow while the remainder of the epidermis takes a bluish stain. The hatching glands are not to be confused with the only other large cells in the epidermis, namely the Leydig cells. In haematoxylin-eosin preparations the latter stain feebly and show a reticular cytoplasm while the hatching glands stain intensely and have a finely granular cytoplasm. The hatching gland cells are widely scattered over the

head in *A. opacum* and only rarely do two of them lie side by side. In *A. opacum* each cell has its base in the germinative or basal layer of the epidermis while its distal end reaches the surface. The secretion within the cell crowds the nucleus proximally. A cuticle is absent in the hatching gland cells. In larvæ fixed at the moment of hatching some of the glands may be seen discharging

FIG 93 Vertical section of the integument of the head of a larval *Ambystoma opacum* immediately before hatching, × 500 The unicellular hatching glands (H G) reach the surface and lack the cuticle which forms a conspicuous margin to the superficial epidermal cells The function of the hatching glands is to digest an opening through the egg capsules which will permit the escape of the larva.

their secretion on the surface. In larvæ treated with pilocarpine the majority of the hatching gland cells have collapsed. A few days after hatching these gland cells have entirely disappeared

We have studied sections of the heads of several other species of Caudata at the time of hatching. We have found unicellular glands similar in structure to those of *A. opacum* in *Hemidactylium scutatum, Plethodon cinereus, Desmognathus fuscus* and *Amphiuma means,* species which hatch out on land, and also in *Ambystoma maculatum* and *Necturus maculosus* which hatch in the water. Hatching glands are known not to occur in frogs which hatch fully formed from the egg capsules aided by a cornified egg tooth. It is highly probable that they occur in all other Amphibia.

That these unicellular glands really function as hatching organs has been shown by Wintrebert (1928) in the case of axolotl. In view of the fact that the environmental conditions are so different in the case of *A. opacum* we have endeavored to determine by experiment their function in this form. In one series of experiments we cut the larvæ free from their capsules before hatching.

After anæsthetizing them in a 1 to 4000 solution of chloretone we dipped them for a few minutes in a 1 per cent solution of pilocarpine hydrochloride. A series of eggs was then placed in watch glasses on slightly dampened Scottissue and each brought in contact with the head of one of the larvæ. Within a few minutes all the eggs thus manipulated had hatched, but none of the controls which had not been brought in contact with anæsthetized larvæ.

In order to exclude the possibility that the larvæ inside of the capsules had influenced their own hatching we performed a second series of experiments. The larvæ were removed from the capsules before hatching and their heads and tails cut off. When the tails or bodies were immersed in a 1 per cent solution of pilocarpine and brought in contact with the empty egg capsules lying on damp Scottissue no modification of the capsules was noted even after three hours of contact. When the heads were similarly treated and their dorsal surfaces brought in contact with the capsules a hole was digested either completely or partly through the capsules in the same period of time. The result was the same whether the treated head was brought in contact with the inner or the outer capsule. When the isolated heads were merely immersed in water and then brought in contact with the egg capsule no disintegration occurred during the three hour period. No change occurred in capsules immersed in water or in 1 per cent pilocarpine, alone, during this period.

We have studied the hatching of *A. opacum* both in water and in dilute solutions of pilocarpine. The embryo, or larva, at this time moves about violently within the capsules pressing the top of its head against the enclosing walls at many points. If the top of the head remains in one position for a short time the capsules will begin to soften and the outer surface becomes distended at this point. Fine white fibers appear in the capsules in this region, these being most numerous directly opposite the point of contact. If the embryo should move its position the area remains distended and probing with a needle reveals that this portion of the capsules has softened and lost most of its elasticity. If the tail should be thrust in one of these pockets it may break through to the outside before the head, which has begun its digestive action on another part of the capsule, has emerged at the new point. We have observed cases where tail and head hatched out at the same moment and the larva remained for several minutes threaded through the capsules. In a few cases the embryo moved so frequently that a large part of the inner capsule became opaque before hatching. In all these cases, however, it seems clear from the experiments reported above that the head alone initiates the hatching process.

Since the enclosed embryo is usually very active at the time of hatching, it must exert a certain amount of pressure upon the egg capsules. Eggs brought in contact with filter paper moistened with 1 per cent pilocarpine hatch in a shorter time than is required for egg capsules to become perforated, when they are moistened with the same solution and brought in contact with an isolated head. This apparently is due to the fact that the embryo is exerting more pressure against the capsules than the isolated head is able to do. We have placed a large series of eggs on Scottissue moistened with 1 per cent pilocarpine. One set of controls was placed on Scottissue moistened with a similar amount of salt solution. Another set was placed on Scottissue moistened with the same

amount of water. Only the first set hatched. Many of these began to hatch within a few minutes and all the larvae had escaped within two hours. An isolated head we had previously found would not invariably digest its way through the capsules within two hours after being placed upon them. Some digestive action would have been begun during this period but often it would not be completed.

We have attempted to arrest the hatching process by treating hatching eggs with dilute solutions of atropine sulphate. Embryos which had begun to digest through the capsules after a brief immersion in a 1 per cent solution of pilocarpine were immersed in a 1 per cent solution of atropine. Hatching continued without a marked delay. When eggs were placed on Scottissue moistened with atropine solutions of 5 per cent to 1 per cent no hatching occurred over a period of several hours.

The egg capsules of any species of Amphibian are very rarely found in nature after the escape of the larvæ. It has been shown above that hatching is accomplished by the digestive action of the integument covering the dorsal surface of the head of the embryo. The only structure found in this tissue and not in the integument of the tail and body are the unicellular glands described above. Therefore, we have concluded that they digest the egg capsules at the time of hatching. It might be assumed that the digestive action is continued after hatching and this leads to the disappearance of the egg capsules of *A. opacum* and other Amphibia. We have tested this hypothesis by placing a series of seven recently hatched larvæ in a watch glass with their egg capsules and a solution of 1 per cent pilocarpine. After a week the egg capsules showed no marked disintegration. A second series of egg capsules from which larvæ had hatched was placed in water and a third series of similar egg capsules in a 1 per cent solution of pilocarpine. This experiment was begun on December 13 and on the following January 29 very little disintegration had occurred. The inner capsules were removed from the outer and found to be still intact. These experiments show that the influence of the hatching gland is extremely local. They also show that in contrast to the views of Lantz, water *per se* has little disintegrating effect upon the egg capsules. It would appear that other agencies, possibly bacteria, cause the rapid disappearance of the egg capsules in nature.

Conclusions

1.—*Ambystoma opacum* lays its eggs under leaf mold, sphagnum, dry water weed or other cover in situations which will be flooded by the winter rains.

2.—Egg-laying may occur as early as September 18 on Long Island or as late as October 4 in Westchester County, New York.

3.—The female may dig a shallow depression for a nest or may utilize crayfish burrows or other natural cavities.

4.—The egg-laying site varies from year to year. The degree of moisture in the soil has an influence on the selection of a nesting site.

5.—The breeding female is not at home in the water and will drown if confined in this medium.

6.—There is considerable variation in color in the adults. The breeding males are whiter above than the females but there is no sexual difference in color pattern.

7.—The adults migrate to suitable breeding sites about the middle of September. The males become sexually active earlier than the females and excite a group to sexual activity by engaging in a series of rubbing movements which are exactly the same whether directed toward male or female.

8.—It is probable that the odor of the female excites the male to the production of a spermatophore.

9.—The behavior of the male induces the female to follow him and this brings the female into the right position for picking up the spermatophore. The female, however, may find and cover any spermatophore after she has been excited.

10.—The spermatophore of *A. opacum* has a distinctive form, its head being roughly quadrangular. The spermatozoa are frequently directed outward. They are held together by pelvic gland secretion. The stalk of the spermatophore is formed by the mucous secretion of the cloacal glands and a supporting framework of eosinophilic secretion produced by glands lying on either side of the pelvic gland.

11.—The spermatozoön agrees essentially with that of *A. mexicanum* except that it has a shorter lash to the tail, a longer head, and no barb.

12.—The female lays from 75 to 232 eggs, with 150 for an average. The egg has four capsules. It is capable of great desiccation without destruction. Eggs found in normal nests in nature will absorb approximately their own weight of water within twenty-four hours, when immersed in that medium.

13.—After laying, the female usually remains with the eggs for a period of at least several weeks. She may or may not return to them once she has left them. She does not forage for food during the early part of the brooding period. Eggs brought into the laboratory do no appear to be attractive to the female.

14.—In the field the female deserts the eggs after approximately a month of brooding. Unguarded eggs may be eaten by salamanders, insects, or other enemies.

15.—Eggs will hatch on land as well as in water. Moisture facilitates development. Desiccated eggs do not hatch as quickly as swollen eggs when im-

mersed in water, and the larvæ that escape are more embryonic than those from swollen eggs.

16.—Unhatched larvæ may winter over on land if the winter is unusually dry. Eggs containing such larvæ were collected in the field March 14. Others kept on ice over a year contained living larvæ.

17.—The terrestrial stage in the life cycle of *A. opacum* is an adaptation permitting the species to compete successfully in the same region with other species of *Ambystoma.*

18.—Hatching is accomplished by the digestive action of a series of unicellular glands scattered over the head of the embryo. They occur in other species of salamanders which lay eggs on land as well as in species laying them in water.

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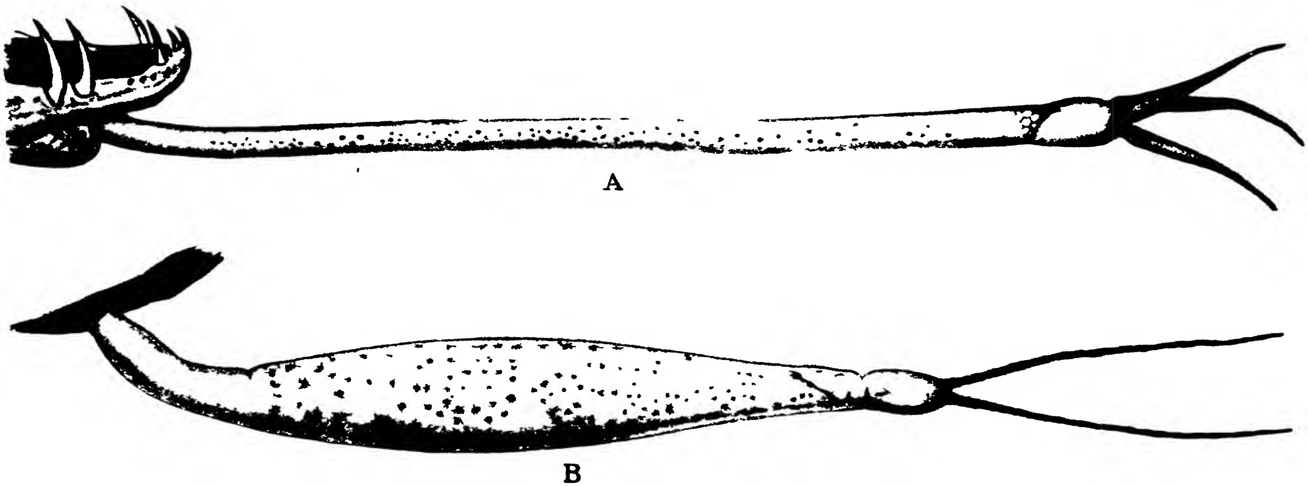

Fig. 1. A—Mental barbel *Stomias boa*. B – Mental barbel STOMIAS FUSUS, sp. nov.

Zoologica, Vol. XII, No. 1

DEEP SEA FISH OF THE HUDSON GORGE*

Taken at Station 113 of the Arcturus and Station 114 of the Eleventh Expedition of the Department of Tropical Research of the New York Zoological Society

By William Beebe, Sc.D.

INTRODUCTION

(Fig 1)

It has always been my desire to see how close to New York City the life of the deep sea is to be found—to see within what narrow limits on the earth one could find such intensive civilization and such an absolutely unexplored field. I interested Mr. L. F. V. Drake and through his influence as President of the Salvage Process Corporation I obtained the use on two separate occasions of the powerful sea-going tug *Wheeler*. I put on board the smaller of my two Arcturus winches with its three miles of quarter inch steel wire.

Two trips were made, on July 8 and August 5, 1928. We left Brooklyn at 6:30 Saturday night and at 8 o'clock the next morning reached the vertical of a mile depth in the Hudson Gorge. This was, as close as we could make it, one hundred and twenty-five miles southeast of the Battery, in 39° 15′ No. Lat. and 72° West Long. This I have called Station 114, or the Hudson Gorge Station, being identical in position with Station 113, the last of the Arcturus Stations, where three years before I spent July 25th to 29th, making sixty hauls with various nets and trawls. Fifty-five species of deep sea fish were taken in all, of which five prove to be new.

In my summary of the results I have combined the organisms taken in Stations 113 and 114. In *Zoologica, Vol. VIII, No. 1,* pp. 22-23, I have given the data of Station 113.

The following table supplies that for Station 114:

*Contribution, New York Zoological Society, Department of Tropical Research No 309

ELEVENTH EXPEDITION

DEPARTMENT OF TROPICAL RESEARCH

Station 114, Hudson Gorge, 125 miles S. E. of New York City,
39° 15′ N. Lat. 72° W. Long.
S. S. Wheeler

Haul	Metre Net	Date	Time	Duration of Haul	Depth Fathoms
T1	½	July 8	8.26 A. M.	15 Min.	100
T2	½	8	9.50	2 Hours	200
T3	½	8	9.50	2	300
T4	1	8	9.50	2	400
T5	½	8	9.50	2	500
T6	1	8	9.50	2	600
T7	1	8	9.50	2	700
T8	½	8	1.50 P. M.	2	0
T9	½	8	2.10	2	650
T10	1	8	2.10	2	700
T11	1	8	2.10	2	750
T12	1	8	2.10	2	800
T13	1	Aug. 5	9.30 A. M.	2	500
T14	1	5	9.30	2	600
T15	1	5	9.30	2	700
T16	2	5	9.30	2	800
T17	1	5	1.40 P. M.	3	600
T18	1	5	1.40	3	700
T19	1	5	1.40	3	800
T20	1	5	9.15	15	0

LIST OF DEEP SEA FISH FROM STATIONS 113 AND 114

Superorder *TELEOSTEI*

Order *ISOSPONDYLI*

BATHYTROCTES DRAKEI sp. nov

One specimen: No. 7690, Hudson Gorge Station 114, T12. 39° 15′ N., 72° 00′ W. July 7, 1928. Taken in meter net, 800 fathoms.

Although measuring only 29 mm. in standard length, this fish shows well developed generic and specific characters. To the former belong the toothed maxilla, seven branchiostegals, the dorsal fin longer than the anal, and originating distinctly in advance of the latter fin.

It is a young fish but the shortness of the mouth is wholly unlike the young of *B. rostratus,* or the adult of any other member of the genus. In *B. rostratus* of equal length (29 mm.), the maxilla measures 5 mm., while in the present individual it is only *2.7 mm.* in length. The gape in other species, young or adult, reaches at least to the middle of the eye, while here the posterior end of the maxillary barely makes the *anterior rim* of the eye-ball. The anal rays number *fifteen* instead of from seventeen to twenty-two. The premaxillaries are *not* noticeably protruding, and although their teeth are directed forward, they are of *equal size* with those in the maxillaries. There is *no* supra-clavicular process apparent, in this respect approaching *Alepocephalus.* The color is typical of young *Bathytroctes,* black head and belly, and light gray body.

I have named this species in honor of L. F. V. Drake, Esq., through whose generosity the boat was loaned for this oceanographic work off New York City.

Length: 29 mm.
Depth of body: 2.9 (10)
Depth of peduncle: 1.7
Head: 10.2 (2.8)
Eye, horizontal: 3.3 (3)
Eye, vertical: 1.6
Snout: 3.2 (3.2)
Maxillary length: 2.7
Branchiostegals: 7

Pectoral rays: 16
Pectoral rays length: 1.3
Pectoral total length: 2.1
Pelvic rays length: 1.6
Dorsal rays: 18
Anal rays: 15
Dorsal base length: 5.1
Anal base length: 4.3
Dorsal in front of anal: 2.1
Pelvics in front of anal: 1.9

This appears to be the first specimen of *Bathytroctes* taken in the western Atlantic Ocean. The nearest record is *Bathytroctes antillarum* Goode and Bean, from 420 fathoms, one hundred miles south-east of the Mississippi delta.

Stomias boa (Risso)

Six specimens:

No.	*L'gth.*	*Sta.*	*Haul*	*Depth*	*P-V*	*V-A*	*A-C*	*Stem*	*L'gth. / Depth*	*L'gth. / Head*	*Head / Eye*
7644	27.5	114	T14	600	47	11	17	.8	11	7.2	5.5
7610	35	114	T7	700	52	10		4.7	10	6.2	6.2
6558a	106	113	T3	400	46	11	17				
6573	111	113	T5	500	48	13	18		11	9	
6558b	116	113	T3	400	49	10	17	12	13.6	5.5	4
7669	125	114	T17	600							

These specimens all fall within the range of variation as given by Brauer for this species. The individual of greatest interest is Number 7644, a young, almost larval phase of 27.5 mm. standard length. When brought up from six hundred fathoms it was white with a dense scattering of pigment along the sides. This completely disappeared in the cleared specimen. Most significant is the absolute lack of ossification throughout head and body. Not a trace of scarlet stain is visible in the cleared tissues, although Number 7610, which is less than eight millimeters longer, and was preserved in the same vial and fluid is well on the stage to adult ossification. In the smallest specimen the head is relatively larger than in the adult, and the stem of the illicium much shorter, being only as long (.8 mm) as the bulb itself. In a fully adult fish the latter has increased not at all, while the stem is twenty-six times longer.

The dentition of the small *Stomias* differs only in slight details from that of the adult: Premaxillary with a medium sized fang each side of the symphysis, a second very large tooth at the anterolateral angle of the premaxillary, curving out and down; five additional ones along the sides of which the first and third are the larger. Mandibular dentition shows an anterior tooth each side of the symphysis, then two very large fangs, set widely apart, leaning almost horizontally outward and then up, followed by six more slender teeth. The pair of vomerine teeth is as large as the anterior premaxillary pair.

Stomias Number 7610 possesses eighty vertebrae; atlas to vertical of pectoral fin 7, pectoral to ventral 47, ventral to anal fin 8, anal fin to and including urostyle 18 vertebrae.

A comparison of dimensions of my smallest individual with the largest ever taken is significant in showing a surprisingly regular development of the characters:

Length	308	mm.	27.5 = 9	per cent. of the adult
Depth	23	"	2.5 = 10	" " " " "
Head	28	"	3.8 = 13.6	" " " " "
Eye	6.5	"	.7 = 10.7	" " " " "
Total Illicium	26	"	1.8 = 7	" " " " "
Pectoral length	25	"	2.7 = 10.8	" " " " "
Ventral length	29	"	2.7 = 9.6	" " " " "

Stomias boa has a wide distribution, having been taken in the Atlantic from the Hebrides to the Cape of Good Hope, and from Greenland to New England. Also in the Mediterranean and the South Pacific.

Stomias fusus sp. nov.

(Fig. 1)

One specimen: No. 7667, Hudson Gorge Station 114, T17. 39° 15′ N, 72° 00′ W. August 6th, 1928. Taken in meter net, 600 fathoms.

This *Stomias* resembles *boa* in photophore count and in general appearance, but is set quite apart by the character of the mental barbel. Instead of having a slender, mobile stem and a large oval bulb with three tentacles, *fusus* has a stiff, spindle-shaped stem, and two tentacles.

Dimensions:

Length: 250 mm.	Ventral length: 23
Depth: 20 (12.5)	Ventral rays: 5
Head: 21 (11)	Dorsal rays: 20
Eye: 5.4 (1.3)	Anal rays: 22
Snout: 3.2	I-P: 11
Dentition	P-V: 47
One-half upper jaw: 5	V-A: 12
One-half lower jaw: 7	A-C: 15
Weight: 28 grams	Lateral scales: 73
Pectoral length: 20	

The barbel arises from the center of the chin, an elongated spindle. 16 mm. in length, pale golden yellow densely flecked with black chromatophores. The terminal bulb, 1.5 mm. in length is unpigmented, bright true purple, and is separated from the spindle by a narrow black band. The bulb terminates in two elongated filaments, rather thick at the base and tapering to a fine point. They are 5.7 mm. long, wrinkled for their proximal half and jet black. In preservative the barbel has faded to white with a pale pink bulb.

The suborbital light organ is small and oval, and is purple on the lower half and white above. The lateral photophores are violet in life, the ventral ones golden yellow.

Stomias valdiviae Brauer

One specimen: No. 7613, Station 114, T10, 700 fathoms.

A single young specimen of only 26 mm. length shows all the typical photophore counts of this species. It is white. with the lines of luminescent spots black.

Length: 26 mm.	Dorsal: 17 rays
Depth: 2.5 (10.4)	Anal: 20 rays
Head: 2.5 (10.4)	P-V: 43
Eye: .4 (6.2)	V-A: 6
Pectoral: 6 rays	A-C: 16

Stomias valdiviae has been recorded from the Atlantic and Indian Oceans. but the nearest locality to the Hudson Gorge is the Gulf of Guinea off the west coast of Africa.

Stomias colubrinus Garman

One specimen: No. 6647, Station 113, T4, 450 fathoms.

A single specimen of this well-marked species came up from 450 fathoms. It is typical in every respect.

Length: 118 mm.	Dorsal: 20
Depth: 11.5 (10.2)	Anal: 23
Head: 13 (9)	P-V: 38
Eye: 4.5 (3.9)	V-A: 10
Pectoral length: 12.5	A-C: 18
Ventral length: 15	

Stomias colubrinus has been taken off the Pacific coast of Panama, and near the Cape Verde Islands.

Astronesthes martensi Klunzinger

One specimen: No. 6648, Length 90 mm., Station 113, T34, 500 fathoms.

In spite of a number of rather marked variations I choose to consider this fish as *martensi* instead of erecting a new name for it. In the major characteristic with which Parr separates two groups of *Astronesthes*, relating to the relative distance from the snout of the origins of the dorsal and the ventrals, this specimen, and others from more distant Arcturus stations, are midway between the two groups,—the percentage being 1/16 in place of 1/25–1/20 and (in *A. martensi*) 1/10–1/8. It has also a smaller eye, (5.9 in the head instead of 4 to 5). These and other differences may be accounted for by age, for Brauer's specimen was only 31 mm. long, and the three of Parr's measured 48 to 50 mm., while the present Hudson Gorge individual is nearly twice this, being 90 mm. standard length. The barbel is in perfect condition, but wholly lacks the "etwa 8 kleine Faden" of Brauer's fish.

Length: 90 mm.		Pectoral rays: 8	
Depth: 15 (6)		Ventral rays: 7	
Head: 22.5 (4)		Dorsal rays: 15	
Eye: 3.8 (5.9)		Anal rays: 16	
Snout: 5.4 (4)		Lateral	O-V: 15
Barbel: 23 (1)			V-A: 19
Snout to dorsal: 46		Ventral	I-P: 9
Snout to ventrals: 40.5			P-V: 14
Pectoral length: 16			V-A: 19
Ventral length: 17.3			A-C: 12

The suborbital organ is large and egg-shaped. and so cloaked with black pigment that it points only straight forward. The barbel is entirely white, the bulb elongated and slenderly club-shaped. No filaments are present or trace of their former attachment.

Astronesthes martensi has been taken in the Indian Ocean, Red Sea, south of Ceylon, near the Cape Verde islands, and among the Bahamas.

Stylophthalmus paradoxus Brauer

Two specimens: No. 7697, Station 114, T6, 600 fathoms, No. 7645, Station 114, T14, 600 fathoms.

The larger specimen, No. 7697, 41 mm. in length, is decidedly immature, the eye-stalks being only one-quarter as long as they are in the adult, but the other characters are quite typical. Among these are the spoon-shaped jaws, the position of the fins and the peculiar intestine.

Description:

Length: 41 mm.
Depth: 1.1 (37)
Head: 4.6 (8.9)
Eye: 1.3 (3.5)
Eye-stalks: 2.5
Snout: 1.8 (2.6)
Jaw: 2.3
Pectoral length: .8
Snout to pectorals: 4.6
Exposed intestine: 1.4
Intestinal exit to caudal: 5
Caudal length: 2.85
Dorsal to intestinal exit: 2.2

Two long rows of small, black photophores extend along close to the ventral surface: above these on the mid-lateral line an alternating row of pigment blotches. The dorsal and lateral surfaces are faintly pigmented.

The immaturity of this individual is distinctly revealed in clearing. The cranium is hardly discernable, but the parasphenoid, jaws, hyomandibular, quadrate, opercles, branchiostegals, and especially the cleithra and supra-cleithra are strongly ossified. The teeth are small, sharp, evenly spaced, twelve in each upper half jaw and eighteen in the lower half. The vertical fin rays are only slightly ossified, but the urostyle, numerous hypurals, and the caudal rays are strongly marked.

The second specimen is only 4.8 mm. in length, but resembles *Stylophthalmus* more than any related genus. The fin rays are barely discernable. It is white with a patch of pigment beneath the heart, a broad band along the sides formed by the dark line of closely spaced light organs; a dense patch dorsal and ventral, near the caudal fin but not touching it. The intestine protrudes .4 mm. The snout is somewhat spoon-shaped, the eye very elliptical, dorso-ventrally, and very short-stalked. Length 4.8 mm. Depth .6; Head 1.2; Eye .4 mm.

This strange little fish has been recorded from the Atlantic, Indian and Antarctic Oceans.

Chauliodus sloanei Bloch and Scheider

Six specimens:

No.	*L'gth*	*Sta.*	*Haul*	*Depth*	*L'gth Depth*	*L'gth Head*	*Head Eye*	*P-V*	*V-A*
7695	26	114	T13	500	9	5.6	4.8	19	26
7687	28	114	T11	700	13 3	7.5	5.3	19	26
6630	65	113	T45	1200	13	7.2	4.5	19	25
7668	230	114	T17	600	9.2	7.4	4.3	19	25
7636	235	114	T13	500	8.6	7.8	5	19	26

No. 7695 is a white, transparent individual, apparently larval, as intensive staining and clearing reveal no trace of ossification. Compared with a full-grown specimen 235 mm. in length, the relative proportions of head and eye, and number of photophores show no differences. The depth in relation to the length is considerably less in the larva, about 13 to 8, while the elongated first dorsal ray is about one-half the relative length that it is in the adult. In this very young individual this ray is directed backward, not forward, and is extremely soft and

pliable, flat and ribbon-like. The second and third dorsal rays are a third longer than the succeeding ones, the extra length being as pliant as the "bait" in *Lophius.* There are no signs of scales, the myomeres numbering sixty.

The relative length of the paired fins is unlike that in the adult. In this larva they are almost equal, whereas in adults the ventrals are about twice as long as the pectorals. In the young the anterior long canine of the lower jaw is one-fourth the entire length of the mandible, while the adult has a fang quite half as long as the jaw. It is remarkable that although the teeth and jaws are long and strong enough to be functional, yet they are as pliable as rubber, and show not a trace of calcification.

Fish No. 7695 is two millimetres shorter than the transparent larva, but is translucent, semi-opaque. When stained and cleared it shows many points of interest.

The unusual relative depth of the body to the length, nine as compared with thirteen in the 28 mm. fish, is explicable when a full-grown *Cyclothone signata signata* becomes visible in the stomach of the young *Chauliodus.* It can be identified with certainty; as to genus from the clearly distinguishable and ossified head bones and dentition, as to species from the lack of dermal pigment, and as to subspecies because of the presence of seven, not six, supra-lateral photophores. The head and fins of the *Cyclothone* are strongly ossified; the head is 4.3 mm. in length, and the total length 15 mm. Of this, the posterior portion is curved around, lying closely pressed to the back. In this curled position the ingested fish occupies a little over half of the full length of *Chauliodus.*

In spite of being less in length than the unossified larva, this young fish is far more advanced in development. The head is well ossified, especially the jaws, teeth, hyomandibular and humeral arches. This is also true of all the fin rays. There is no trace of vertebral calcification except very fine outlines of the first five. The vertebrae of the entire column can, however, be distinguished, and the scale outlines can be made out in favorable light.

There are five teeth in each half jaw, the first and second premaxillary, and the first and third mandibular being much larger than the rest. Each one is accompanied by a small understudy or auxiliary tooth, ossified near the tip, but with the basal three-fourths clear and pliable, so that it can bend back out of the way when food is being seized, thus keeping in perfect shape until needed to replace the loss of its companion. On the premaxillary, between the second, third and fourth teeth are two, small, outwardly pointing, solitary teeth. The inferior half of the maxillary enters the border of the mouth with ten small, oblique denticles. The frontal crest is conspicuous, and honey-combed with three lateral foramina and a longitudinal open tube. Eighteen branchiostegals, short, vertical, and evenly spaced are distinct.

The opercles and preopercles are clearly ossified, and both of them linear, the same being true of the several cleithra. Thirteen pectoral rays are supported on five faint but distinct brachials. There are seven ventral rays and the pelvic girdle is well developed, the pubic bones extending far forward to a length of

3.2 mm., fully half the distance to the pectoral fin. In the dorsal are six rays, the anterior, elongated one soft, still directed posteriorly, and measuring 7.8 mm. This is very close to the relative length of the same organ in the adult, showing the importance of the filament throughout the life of the individual. The anal fin shows twelve rays.

The urostyle is strongly ossified, and is attended by rather faintly indicated hypurals and eight large and strong epurals. There are nineteen rays which properly enter into the functional caudal fin, with eight small superior, and three inferior supplemental basal raylets.

In the two fully adult specimens taken in the Hudson Gorge, one a male, measures 235 mm. in length, while the other, a female, is 230 mm. long. The chief difference of note is in the size of the eyes, those of the female being considerably larger. The weight of the longer specimen is 55 grams, while the shorter female with her full-sized ovaries weighs 62.5 grams. The relative depth to length apparently increases with age, as the table shows, the two largest fish being respectively 9.2 and 8.6, as compared with 13.3 and 13 in smaller individuals.

There are many other ontogenetic points of interest, but I leave these for a more comprehensive monographic treatment than can be permitted in this brief paper.

Chauliodus sloanei has been taken from both east and west sides of the Atlantic, in the Pacific from Japan to New Guinea and in the Indian Ocean.

Chauliodus dentatus Garman

One specimen: No. 6559. Length 68 mm. Station 113, T45, 400 fathoms.

It is with reluctance that I admit the validity of this species, considering the variation of numbers of photophores in *C. sloanei.* But I have not been able quite to bridge the gap between the two forms, while other supposedly diagnostic characters are of most slight foundation.

Description:

Length: 68 mm.	I-P: 10
Depth: 8.6 (8)	P-V: 21
Head: 10 (6.8)	V-A: 29
Eye: 2 (4.5)	A-C: 11

The abnormal depth into length of 8 in such a moderate sized *Chauliodus* is accounted for by the great distension of the stomach, the outlines of an ingested fish being clearly visible through the opaque skin.

Chauliodus dentatus is known only from the type which came from the Society Islands.

Genus *CYCLOTHONE*

Of this genus I took 1355 individuals in seventeen hauls at Station 114. Careful analysis shows no correlation between the light and dark forms and any

definite zone of distribution. Of the total catch 861 were dark, and 494 (or 36 per cent) were light.

Cyclothone signata signata; 251 specimens from Station 114.

Cyclothone signata alba; 64 specimens from Station 114.

Cyclothone microdon; 1025 specimens from Station 114.

Cyclothone acclinidens; 15 specimens from Station 114.

The hundred fathom distribution was as follows:

500	fathoms	68%	light	32%	dark
600	"	19%	"	81%	"
700	"	47%	"	53%	"
800	"	23%	"	77%	"

No *microdon* was taken within 400 fathoms of the surface, and only a single *signata* above 100 fathoms. At all Arcturus stations where abundant catches of *Cyclothone* were made the proportion has always been about twice as many dark as light forms.

In a 26.5 mm. *Cyclothone signata* the ovaries were fully developed, each 4.5 mm. in length and containing a total of 530 eggs, averaging .4 mm. in diameter. A female *Cyclothone signata alba* of 29 mm. had 4 mm. ovaries containing 764 ova. In a count of several individuals I found that both *signata* and *microdon* averaged thirteen trunk and nineteen caudal vertebrae.

C. signata has been taken in the Atlantic, Pacific and Indian Oceans, *alba* in the Atlantic and Indian, *acclinidens* in the Atlantic, Pacific, Indian, and the Antarctic, while *microdon* is recorded from all five oceans.

Idiacanthus fasciola Peters

One specimen: No. 6649, Station 113, T35, 600 fathoms.

This is the only member of this family secured on the two trips to the Hudson Gorge. It measured 122 mm. in length. The species has been taken in the Atlantic, Pacific and Indian Oceans.

Vinciguerria ucetia (Garman)

Two specimens: No. 7611, Station 114, T9, 650 fathoms.

In several places where I have dredged in distant parts of the oceans this little fish has proved to be abundant, but in the Hudson Gorge I took only two. The length of these was 11.8 and 18.2 mm. and it was surprising to find that in the smaller, the skeleton, even the vertebral column, was very strongly ossified. There were 22 trunk, and 17 to 18 caudal vertebrae. *Vinciguerria* has been collected in the Atlantic, Pacific and Indian Oceans.

Argyropelecus olfersi Cuvier

One specimen: No. 6625b, Station 113, T43, 1000 fathoms

Although only 10.7 mm. long, and taken in the same net as *A. hemigymnus*, there is no question of identificaion, the preopercle and abdominal ridge with their characteristic spines being well grown and ossified. The young of this species has, in addition to the strong, downwardly directed spine of the preopercle, a small, outward pointing one which later becomes reduced. In the present individual the anterior thirteen vertebrae are completely ossified, but in the remainder the calcification is confined to the upper and lower portions. This species has been taken in many parts of the Atlantic, as well as in the Pacific and Indian Oceans.

Argyropelecus hemigymnus Cocco

Two specimens: No. 6591, Station 113, T32, 164 fathoms; No. 6625a, Station 113, T43, 1000 fathoms.

Both individuals are very young, measuring only 10.7 and 13.2 mm. standard length. The species has been found in the Atlantic, Pacific and Indian Oceans.

Sternoptyx diaphana Hermann

Nine specimens: 6603a, Station 113, T37, 800 fathoms; 7614, Station 114, T10, 700 fathoms; 7635, Station 114, T13, 500 fathoms; 7643, Station 114, T14, 600 fathoms; 7648, Station 114, T15, 700 fathoms (2); 7665, Station 114, T17, 600 fathoms (2); 7679, Station 114, T18, 700 fathoms.

All the specimens were post-larval, or at least not more than half grown. The species has been recorded from the Atlantic, Pacific and Indian Oceans.

Derichthys sp. nov.

One specimen: No. 7670, Station 114, T17, 600 fathoms. Length 185 mm.

This specimen appears to belong to this genus, but has greatly elongated, anteriorly directed, tubular nostrils. I reserve final identification until I have had it stained and cleared.

Nemichthys scolopaceus Richardson

One specimen: No. 6569, length 190 mm. Station 113, T4, 450 fathoms.

This individual agrees fairly well with the common Atlantic species of Snipe-billed Eel. It has 301 vertebrae and 14 branchiostegals.

It is wide spread through the Atlantic Ocean, and has also been recorded from the Pacific north of New Guinea.

Serrivomer beani Gill and Ryder

Two specimens: No. 6568, Length 385 mm. Station 113, T4, 450 fathoms; No. 6611, Length 285 mm. Station 113, T39, 1000 fathoms.

This pair of Saw-toothed Eels differs from the superficial description of Gill and Ryder in a number of particulars, but the inadequate original description together with the present paucity of material makes it inadvisable to recognize these differences as specific.

The major characters of No. 6568 are as follows:

Standard length 385 mm.

Depth: 7 (55)	Snout: 24 (2.5)
Head: 60 (6.4)	Dorsal rays: 130
Eye: 3.5 (17)	Anal rays: 116

This species has been taken in various parts of the Atlantic, and near Hawaii. If it is considered as identical with *S. sector* the distribution may be extended to the west coast of Sumatra.

Family MYCTOPHIDAE

At the Hudson River Gorge Station three hundred and forty-one individual myctophids were taken, of which seventy-two were larvae, or too young to admit of certain identification. The adults were distributed among twenty species, as follows:

Myctophum valdiviae Brauer; *4 specimens;* recorded from Atlantic, Pacific and Indian Oceans.

Myctophum glaciale Reinhardt; *124 specimens;* recorded from northern Atlantic and Arctic waters.

Myctophum laternatum Garman; *1 specimen;* recorded from Atlantic, Pacific, and Indian Oceans.

Myctophum fibulatum Gilbert and Cramer; *1 specimen;* recorded from Atlantic and Pacific Oceans.

Myctophum coccoi Cocco; *11 specimens;* recorded from the Mediterranean, Atlantic, Pacific and Indian waters.

Myctophum affine Lutken; *4 specimens;* recorded from Atlantic, Pacific and Indian Oceans.

Myctophum punctatum Rafinesque; *1 specimen;* recorded from the Mediterranean and Atlantic.

Myctophum benoiti Cocco; *7 specimens;* recorded from Mediterranean, Atlantic, and East Indian waters.

Myctophum reinhardti Lutken; *4 specimens;* recorded from Atlantic, Pacific and Indian Oceans.

Myctophum hygomi Lutken; *3 specimens;* recorded from Mediterranean, Atlantic, and Indian waters.

Lampanyctus maderense Lowe; *12 specimens;* recorded from Atlantic and Mediterranean waters.

Lampanyctus warmingi Lutken; *3 specimens;* recorded from Atlantic and Indian Oceans.

Lampanyctus gaussi Brauer; *73 specimens;* recorded from Atlantic Ocean.

Lampanyctus tenuiforme Brauer; *2 specimens;* recorded from the Indian Ocean. When more detailed descriptions are available this may prove to be *Lampanyctus nobilis* Taaning from the north Atlantic.

Lampanyctus micropterus Brauer; *1 specimen;* recorded from Atlantic and Indian Oceans.

Lampanyctus gemmifer Goode and Bean; *1 specimen;* recorded from Atlantic Ocean.

Lampanyctus pusillus Johnson; *11 specimens;* recorded from Atlantic Ocean.

Diaphus dumerili Bleeker; *2 specimens;* recorded from Atlantic and East Indian waters.

Diaphus gemellari Cocco; *3 specimens;* recorded from Mediterranean, Atlantic, and Indian waters.

Lampadena sp.; *1 specimen*, too injured for specific identification.

The larval myctophids averaged fifteen millimetres in length, and showed three pairs of pigment spots on the epidermis, one before each eye, one each at the anterior base of the pectoral and ventral fins. A few photophores were faintly adumbrated, especially four of the postero-anal light organs.

In relative specific abundance there was a decided disparity, since three-fourths of the total number of adult myctophids belonged to two species, *Myctophum glaciale* and *Lampanyctus gaussi.*

Malacosteus niger Ayers

One specimen: No. 6651, length 80 mm., Station 113, T5, 500 fathoms; recorded from the Atlantic, Pacific and Indian Oceans.

Bregmaceros atlanticus Goode and Bean

One specimen: No. 7642, length 21.5 mm., Station 114, T14, 600 fathoms.

Dorsal elements I-47, anal 57. Color: Creamy white with a thick scattering

of stellate chromatophores over the dorsal part of the head and body, less abundant below. Opercula immaculate. Iris greenish silver.

This species has been taken in various parts of the Atlantic.

Urophycis chesteri Goode and Bean

2250 specimens collected and counted; about 1000 thrown back without counting.

Taken in every net of a twenty-four hour series of half-hour surface hauls. Station 113, T6 to T29, July 25 and 26, 1925.

These hake were, without exception, larval, post-larval or young up to five inches in length.

Hake are found all along the Atlantic coast of the United States in depths of from one hundred to five hundred fathoms, and are probably the most abundant fish on the edge of the continental shelf.

Citharichthys arctifrons Goode

Nine specimens: Numbers 6636 and 6637, Station 113, D1, 1000 fathoms.

Measurement of an average specimen.

Length 42 mm.	Mandible: 3 (3.7)
Depth: 13 (3.2)	Dorsal: 81
Head: 11.3 (3.7)	Anal: 65
Eye: 3.5 (3.2)	Vertebrae: 36

A common species in the deeper waters of the Gulf Stream.

Glyptocephalus cynoglossus (Linnaeus)

Twenty-one specimens: No. 6560, one, Station 113, T3, 400 fathoms; No. 6638, nineteen, Station 113, PT3, 69 fathoms; No. 6854, one, Station 113, PT3, 69 fathoms.

All the specimens are young, averaging 40 mm. They are intermediate between *h* and *i* in Fig. 71, p. 175, "Eier und Larven von Fischendes Nordischen Planktons." The eye has just begun its migration. Ours lack the pigment spots on the interneurals and interhaemals.

The eyes and color are on the right side, and there are 58 vertebrae, 108 dorsal and 90 anal rays.

This fluke is found on both coasts of the northern parts of the Atlantic Ocean.

Genus *MELAMPHAES*

Three species of this deep sea genus were taken at the Hudson Gorge Station.

Melamphaes mizolepis Gunther

Three specimens: No. 7682, length 88 mm., Station 114, T19, 800 fathoms; No. 7678, length 43 mm., Station 114, T18, 700 fathoms; No. 7666, length 10 mm., Station 114, T17, 600 fathoms.

Recorded from the Atlantic, Pacific and Indian Oceans.

Melamphaes nigrescens Brauer

Two specimens: No. 6610, length 41 mm., Station 113, T39, 1000 fathoms; No. 6616, length 3 mm., Station 113, PT1, 1000 fathoms.

Recorded from the Atlantic and Indian Oceans.

Melamphaes suborbitalis (Gill)

One specimen: No. 6615, length 63 mm., Station 113, PT1, 1000 fathoms.

Recorded from the Atlantic and Indian Oceans.

Helicolenus maderensis Goode and Bean

One specimen: No. 6575, length 152 mm., Station 113, V1, 546 fathoms.

In life this fish weighed 128 grams. It was brilliant scarlet with some dark mottling along the back and considerable silver on the under parts. The iris was greenish gold.

Recorded from moderately deep water off the entire coast of the eastern United States, and near the Madeira Islands.

Lycenchelys verrillii (Goode and Bean)

One specimen: No. 6576, length 128 mm., Station 113, D2, 69 fathoms.

This species has been taken off the north-eastern coast of the United States.

Melanocetus niger Regan

One specimen: No. 6552, Station 113, T35, 600 fathoms.

Length: 15 mm.	Longest tooth: 1.9
Head: 9.1	Dorsal: 14 rays
Mandible: 11.8	Anal: 4
Interfrontal: 4	Pectoral: 21

Although a young fish, all the major characters are well developed. It is certainly not *M. johnsoni,* and shows no radical differences from *M. niger* although this species is known only from the Pacific.

Caulophryne jordani Goode and Bean

One Specimen: No. 6530, Station 113, T35, 600 fathoms.

A single specimen of small size is typical in every respect.

Lipactis megalops sp. nov.

One Specimen: No. 6633a, Station 113, T43, 1000 fathoms.

Near *L. tumidus* of Regan but with much larger eyes (5.9 in head instead of 8.3), and an external, sessile cephalic bulb. The basal part of the illicium is subdermal but well developed, while the external, flat-topped bulb rests in a groove on the outside of the dermal envelope. The snout is 5.9 in the head instead of 4 as in *tumidus*.

Length: 10 mm.
Depth: 7.5 (1.3)
Depth of actual body: 5.9
Head (to gills): 5.9 (1.7)
Eye: 1 (5.9)
Snout: 1 (5.9)
Maxillary: 1.6 (3.7)

Type Location: The type is deposited in the collection of the Department of Tropical Research in the New York Zoological Society.

Name: *megalops*, from the unusually large size of the eyes.

Haplophryne hudsonius sp. nov.

One specimen: No. 7696, Station 114, T6, 600 fathoms.

For detailed description see the succeeding number of ZOOLOGICA, Volume XII, Number 2.

Zoologica, Vol. XII, No. 2.

HAPLOPHRYNE HUDSONIUS

*A New Species; Description and Osteology**

BY WILLIAM BEEBE, SC.D.

Preamble—Genus *HAPLOPHRYNE*

(Figures 2, 3, 4, 5)

It would not be unreasonable to establish a new genus for the Hudson Gorge fish which I am about to consider, but we know so little about individual and specific variation in the Ceratioidea that I chose a more conservative policy. Brauer in 1902 established the genus *Aceratias* for three species of fish. One of these was *A. mollis.* Regan, ten years later, removed *mollis* to a separate genus which he called *Haplophryne.* His original definition of this genus was "with depressible teeth and without nasal papilla." In 1926 he redefined *Haplophryne* as follows: "Sphenotic spines not prominent. Mouth rather small; teeth moderate. Illicium subcutaneous, small, with short stem and terminal bulb; a pore on upper surface of snout, at the margin of which the skin is attached to distal end of illicium. No barbel. Preopercular spine simple, concealed beneath the skin. Skin thin, loose, translucent, unpigmented."

Viewed through the translucent skin, the fish I have under consideration fits this generic definition, except that the reference to the cephalic pore should be expanded to include double, sessile bulbs outside the skin.

Before taking up in detail this new specimen from the Hudson Gorge, I will review the four individuals called *mollis* by Regan. This will show our present knowledge and indicate the extent of variation. Only when more material is available can these variations be catalogued with certainty as individual or specific.

The quartet of described specimens of *H. mollis* is as follows:

A—14 mm. long. Valdivia Expedition. Indian Ocean.
26° 3′ 6″ So. Lat.; 93° 43′ 7″ East Long. Depth 1203 fathoms.

B—32 mm. long. Dana Expedition.
25° 7′ N. Lat.; 19° 20′ West Long. South of the Canaries.

*Contribution, New York Zoological Society, Department of Tropical Research, No. 310.

COMPARISON OF FOUR SPECIMENS OF H. MOLLIS[1]

	(A) Valdivia	(B) Dana	(C) Terra Nova	(D) Stanford	Extremes of Variation
Dorsal and Anal rays	3	3	3	3	
Caudal rays	8	8	9	9	8–9
Pectoral rays	14–16	15	15	18	14–18
Depth to length	2.1	1.6	1.5	2.7	1.5–2.7
Head to length	2.5	1.9	1.7	2.4	1.7–2.5
Snout to head	3.6	3.3	4	?	3.3–4
Eye to head	5.5	9.2	5	7	5–9.2
Eye to snout	1.5	2.8	1.2	?	1.2-2.8
Mandible to head	2.6	1.7	3.5	1 5	1.5–3.5
Illicium	absent[2]	subdermal; opening into pore	rudimentary; subdermal	?	various
Anus position (lateral)	asymmetrical	symmetrical	symmetrical	?	sym. or asym.
Anus position (longitudinal)	mid-body	¾ back	⅗ back	?	½–¾ back
Cephalic spines	?	small sphenotics	?	2 strong supraorbitals	0-2
Rostral denticles	3, isolated	? premaxillary	?	?	0-3
Teeth, upper jaw	9	11	5	?	5–11
Teeth, lower jaw	13	11	6	14	6–14
Gape	to front of eye	to mid-eye	to front of eye	behind eye	In front to far back of eye
Eyes	telescopic	normal	normal	normal	normal–telescopic
Mouth	moderate horizontal	small oblique	small horizontal	large vertical	small–large vertical–horizontal
Branchiostegals	4	?	?	5	4–5

[1] This data is compiled both from printed descriptions and from drawings.
[2] Probably overlooked, owing to dermal opacity.

C—7 mm. long.[1] Terra Nova Expedition. New Zealand. Surface.

D—100 mm. long.[2] Stanford Expedition. Galapagos Islands. From stomach of Green Turtle.

The fifth column of the accompanying table shows the extraordinary range of variations, some of which must ultimately prove to be specific or generic. In a few instances the variation may be the result of distortional relaxation of the tissues, or confusion resulting from surface examination. I have avoided the latter difficulty in my own specimen by thoroughly clearing it and staining the skeleton with a vital bone stain.

HAPLOPHRYNE HUDSONIUS sp. nov.

Type number 7696: Hudson Gorge Station 114, T6. 39° 15′ N. Lat., 72°, 00′ W. Long. July 7, 1928. Taken in a metre net at a depth of 600 fathoms.

Field Characters: A small, white, balloon-skinned, elongate, ceratioid fish, with three large, curved rostral denticles; dorsal and anal three-rayed; double, minute, sessile, cephalic bulbs; anus sinistral, three-fourths toward tail.

Measurements of Type:

Standard length: 15 mm.	Maxillary: 2.8 (in length 5.3)
Head: 7.5 (in length 2)	Dorsal: 3 Anal: 3
Total depth: 6.6 (in length 2.2)	Pectoral: 17
Body depth: 5.1	Caudal: 9 (2 upper, 3 lower simple)
Total breadth: 5.7 (in length 2.6)	Caudal length: 8.1
Body breadth: 4.3	Snout to dorsal: 11.3
Eye: 1.3 (in head 5.8) (in interorbital 2)	Snout to anus: 10:7
	Ocular angle: 24° down[3]
Interorbital 2.7	Ocular divergence: 18° forward
Snout: 1.6 (in head 4.7)	Mouth angle: 12° up

The first thing we notice in the cleared specimen is the absolute hyalinity of the very thick, balloon-like casing of skin. The thickest portion of the fish is at mid-head, and from here the crown curves regularly and steeply downward to the mouth. Posteriorly the line of the back is almost a straight slope to the tail. The chin curves rapidly back to the end of the mandible, whence the contour is straight.

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[1] I assume the given length of 10 mm. is total length.

[2] The given length of 27 mm. is, judged by all the other measurements, an original misprint for 100 mm.

[3] The angles were taken as soon as possible after death.

The superior contour of the actual body within the dermal envelope follows closely that of the outside, except that the profile of the skull from the supraoccipital to the premaxillary is flat rather than curved. So complete is this envelope that the tip of the jaw is the only spot where the skeleton contacts with the outside. The other points of penetration are the paired cephalic bulbs and the gill-openings, the anus and fin rays.

Although at first glance the dermal balloon appears perfectly homogeneous, yet in the course of manipulation an outer layer of epidermis peels almost completely away. This is of considerable thickness, and under low power shows innumerable, minute, needle-like spicules, giving, in some lights, a frosted or flocculent appearance. Under higher magnifications a great number of very small, rounded or oval figures are seen, but offer no clue as to whether they are vestiges of former scales.

In spite of the small size of this fish the skeleton is remarkably well ossified, the various skull and branchial elements, the vertebrae and fin rays showing an even, scarlet stain. In sharp contrast with this, the optic envelopes, the coelomic contents, and the pectoral and trunk muscles are differentiated as pale, translucent, orange tissues.

Whether the imperfectly ossified edges and ends of some of the bones represent solely a juvenile condition, or whether this is a permanently arrested phase due to unknown bathypelagic factors we do not as yet know. As Lütken says in writing of the skull of an adult Ceratias, "Le crâne a la même structure spongieuse ou fibro-lamelleuse que la colonne vertébrale, les os de l'épaule etc.; mais il y entre de plus un élément cartilagineux assez considérable, certaines parties du chondrocrâne primordial restant dans l'état primitif, soit sur les confins des os qui se sont formés a ses depens, soit sous les ossifications parastotiques développées au-dessus d'elles ou dans leur portion périphérique."

The fact of the perfection of development, in spite of the diminutive size, of the illicium, and its elaborate musculature, also the quite undegenerate aspect of the almost wholly sub-cutaneous dorsals and anals, seem to suggest that the swollen dermal envelope is a larval or juvenile character. It may be useful as a buffer protection of sorts during the late stages of development, aiming toward such an adult form as *Dolopichthys.*

I have included in my brief review a few characters, such as the ray segmentation which may seem trivial, but until we know more about the comparative physiology of these deep sea fishes we cannot be sure of what is trivial or what is preeminently significant.

Cranium

The top of the cranium is not very unlike that of *Borophryne* as shown by Regan, but with the ethmoids much less in extent, with the interfrontal hiatus of a different shape, and the anterior half of the skull wider. The median hollow or groove shown so conspicuously in all the Ceratioid skulls of Regan is only slightly developed. Anteriorly it is distinguishable but disappears at the supra-occipital where the skull flattens out. Behind this the median line again shows a slight hollowing or furrowing between the two laterally prominent epiotics.

Looking down on the cranium, its junction with the vertebral column can clearly be made out between the two great masses of trunk muscles which sweep forward on each side of the neural arches to their attachment along the entire posterior aspect of the epiotics. The cone-like, concave facet of the basioccipital extends backward and obliquely upward to engage the corresponding portion of the first vertebral centrum. On each side of the foramen magnum two thin, wing-like projections from the exoccipital articulate with two from the first vertebra. The neural arch of this latter bone is broader than its posterior fellows, quite spineless, and instead of slanting backward it is directed forward. closely applied to the faintly ossified posterior cranial region. If this fish has nearly completed its calcification this is an interesting arrested phase. if not, the neural arch would in time have become wholly fused with the periphery of the foramen magnum.

The entire posterior upper surface of the cranium is formed by the large epiotics. which join medially and quite shut out the supra-occipital from the posterior outline. The supraoccipital is large and roughly circular, occupying the center of the cranium. On each side are large parietals. concave where they abut on the supraoccipital, widely rounded laterally over the sphenotics. and sending a small flattened spine back along the outer contour of the epiotics.

Returning again to the posterior edge of the cranium. the post-temporals show a broad condylar face for articulation with the supra-

cleithrum. They are roughly square in shape, extending forward along the sides of the cranium, and engaging the epiotics and the pterotics. The pterotics continue the lateral aspect forward, lying alongside the epiotics and parietals, and showing a pronounced articulation for the hyomandibular. The sphenotic forms the posterior half of the supra-orbital rim, and just posterior to the eyeball gives rise to a strong, outjutting lateral spine .7 mm. in length, sharp, slender and straight, which extends out beyond the circumference of the eye to the very surface of the cutaneous envelope.

The frontals are well separated, leaving a cartilaginous hiatus which is linear rather than (as is indicated in *Borophryne*) circular. Each constitutes a fourth of the supero-anterior border of the orbit; anteriorly the frontal curves down beneath the nasal tissue, ending in two sharp, lateral points connected by a deep, ossified bay. A ridge of bone runs from the center to each point, that to the outermost being much the stronger. Posteriorly the frontals touch the supraoccipital narrowly, and the parietals along a wide extent.

The prefrontals are distinguishable as two slender, hour-glass like bones, closely resembling the interhyals in shape. They extend from the region of the anterior end of the parasphenoid back to the inner, anterior fork of the frontal. The vomer is a transversely winged bone, broad-arrow-barb-like, extending across the anterior ends of the para-sphenoid. The ethmoids are too transparent for clear definition.

Viewing the skull from the side, the strong, thin parasphenoid is seen rising well forward beneath the nasal tissue, and extending straight backward, visible through and exactly bisecting the translu-cent, pale brown sphere of the eyeball, and on back to the base of the skull. The prefrontals are dimly discernible through the mist of narial tissue. Back of and lateral to the suture of the premaxillaries is a small lachrymal.

PALATO-PTERYGOID ARCADE

The hyomandibular is less strongly ossified than any of the bones with which it is associated, but it shows a broad superior surface, articulating with the pterotic and extending forward as far as the sphenotic. Directly below, a strong connection is made with the oper-cular condyle. The deeper cheek area is much more strongly muscled

than it is ossified, but a faint connection of the hyomandibular with an interhyal can be made out. No symplectic is visible.

The quadrato-angular articulation is by means of a delicate, wide, needle-fine, transverse condyle. From this point the tissue of the quadrate is stretched between three lines of strong radiating ridges, one upward and slightly forward to meet the palatine, a second up and somewhat backward which connects with the pterygoid, and a third obliquely back, passing beneath the preopercle.

The pterygoid shows ossification only as an irregular plate, twisted into three planes, and sending forward a long finger which meets the still more slender palatine.

Jaw Apparatus

The jaws are well ossified. The premaxillaries viewed from above are slightly separated at their suture, and show an abrupt height at this point. Laterally this height rapidly narrows to a flat, even-edged jaw rim extending well over the mandible and reaching almost to its supero-posterior angle. The maxillary can be distinguished as a thin rod of bone beginning at the point of narrowing of the premaxillaries and lying loosely along its upper edge.

Three large, curved, talon-like denticles arise out of the ethmoid cartilage, quite clear of the jaw, their roots close and showing a large area of ossified, anastomosing filaments. One denticle is median, while the other two have their tips rotated laterally. From the very front of the premaxillaries, close to their symphysis, two minute teeth project straight ahead. The rest of the rim of the upper jaws shows a few incipient teeth of very small size, irregularly placed. In front of the lower jaw are five pairs of strong teeth, the central pair straight and extending horizontally outward. The four lateral pairs are curved like the three superior teeth, but are smaller. When these are viewed from directly below the jaw, they are seen to be elevated well above and anterior to the bone, arranged along a line of cartilage. This seems to bring them into the same category of dermal denticles as the nostril trio.

Behind these ten teeth and along the anterior rim of the lower jaw are the real mandibular teeth. Four large, curved ones are seen

on each side of the middle line. forming a true second row of lower teeth.

The mandible has a very noticeable projection at the symphysis. directed downward. Posteriorly the jaw broadens rapidly and the distance from the superior to the inferior angles at the back is contained only 2.3 times in the entire mandible length. Half way back along the mandible occurs the fork of the dentary—both prongs extending almost to the posterior edge of the jaw. The articular fills in between the upper and lower arms and forms a deep. rounded bay of articulation for the condyle of the quadrate. halfway down the long, oblique, posterior aspect.

Opercular Bones

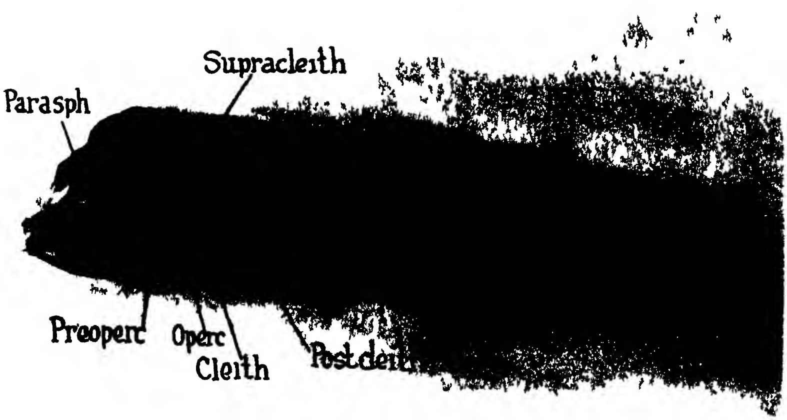
The opercle is a large. fish-tailed bone. presenting an anterior articulation with the hyomandibular. At the point of junction a strong but short spine rises upward and obliquely forward. From this point two strong ridges of bone diverge at right angles, one reaching up and back to and across the supracleithrum, and the other down and back. just bisecting the first branchiostegal. Between the ridges extends a thin lamina of bone, deeply incurved from the two points.

The preopercle is elongated, rather narrow, slightly angled—in fact very boomerang-like in outline, with a ridge of bone along the anterior edge. The upper end dies out insensibly over the hyomandibular, yet showing hardly any difference in plane; and the lower portion terminates near the angular, overlapping but quite distinct from the quadrate. The entire bone is flat and shows no trace of spines at any point.

The interopercle, viewed laterally, is a long, narrow sliver of bone, in appearance like a strong mid-rib to the expanded, leaf-like ceratohyal beneath. It lies midway between and parallel to the lower half of the preopercle and the heads of the second to fifth branchiostegals. It is slightly broader at the upper end. and is intimately connected with the junction of the interhyal and epihyal. The ossification of the interopercle ends about three-fourths of the way to the angular. For the last quarter, its course is outlined clearly in cartilage to the very point of the prominent angular condyle.

I can distinguish no trace of a subopercle.

A



B

Fig. 2. HAPLOPHRYNE HUDSONIUS, sp. nov. A. Uncleared, as the fish came up in the net. B. Side view after clearing. Illustrations from unretouched photographs

Fig. 3. Haplophryne hudsonius, sp. nov. A—Lower view of the whole fish. B—Top view of the whole fish. Illustrations from unretouched photographs.

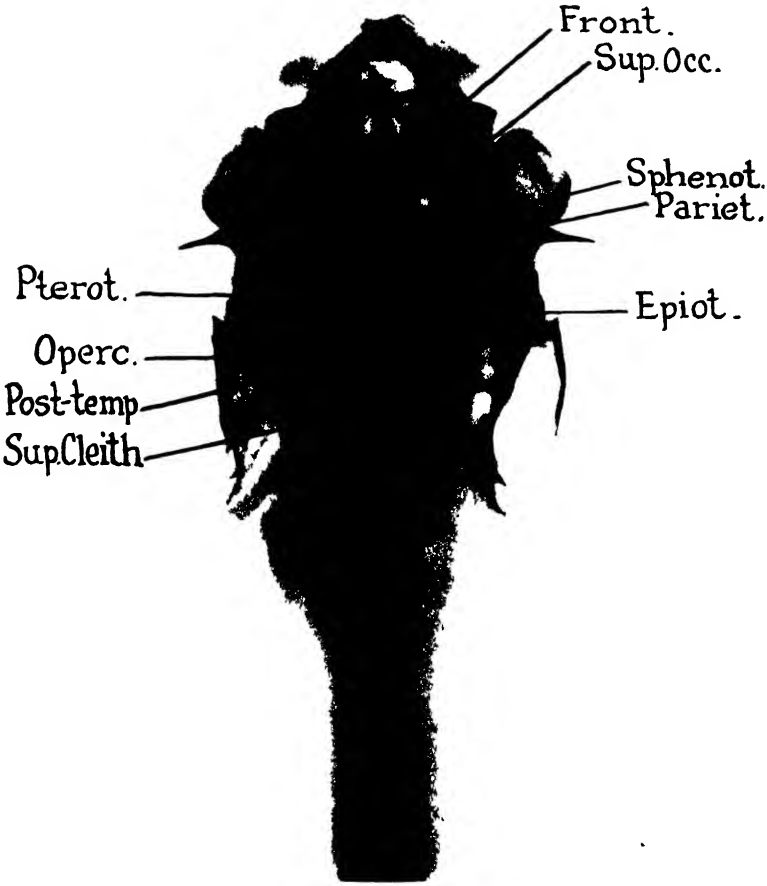


Fig 4. HAPLOPHRYNE HUDSONIUS, sp nov. Top view of skull.

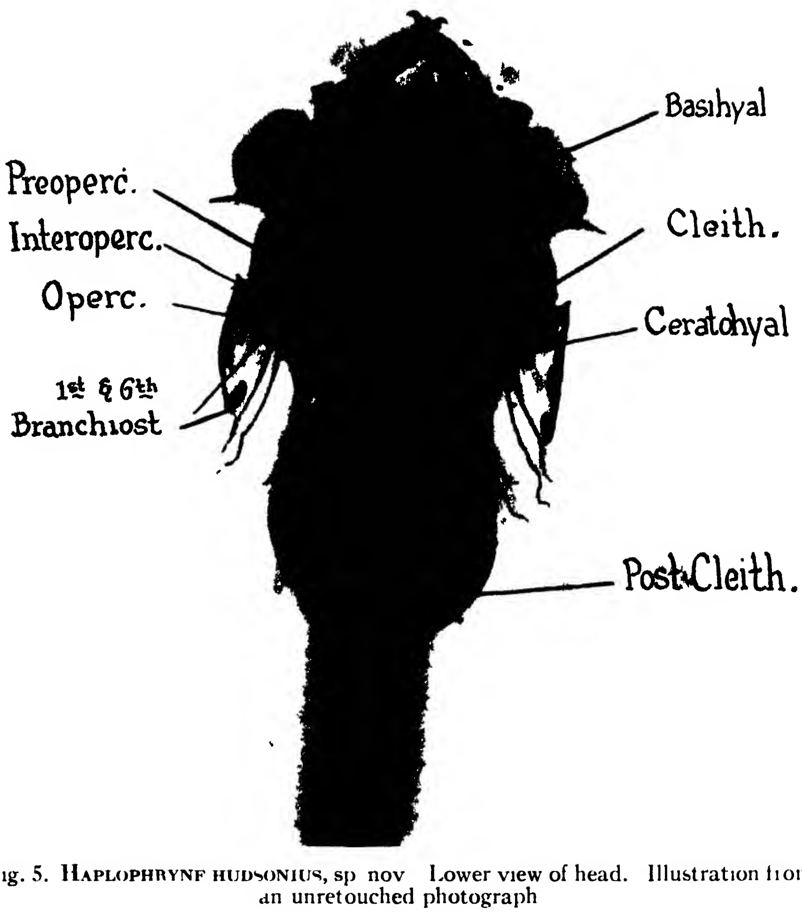


Fig. 5. HAPLOPHRYNE HUDSONIUS, sp. nov. Lower view of head. Illustration from an unretouched photograph

Hyoid Arch

From the lower part of the hyomandibular arises the elongate. very slender, hour-glass shaped interhyal, extending obliquely down and backward, beneath the angle of the preopercle. Posteriorly it articulates at right angles with the epihyal. This is a very short bone and hardly to be differentiated from the long ceratohyal. Just beneath the quadrato-angular articulation the long basihyals arise and extend far forward, almost uniting on the mid-throat. These latter are more strongly ossified at the ends than in the center. No glosso or urohyals are distinguishable.

There are six branchiostegal rays.

The first branchiostegal is very long, and originates well forward on the basihyals. Curving inward and backward its attenuated tip reaches as far as those of the other branchiostegals. It is 4.6 mm. over all, and shows very little widening. None of the branchiostegals reaches as far back as the gill opening.

The second to fifth arise side by side from the lower leaf of the ceratohyal, their heads parallel with the rod-like interopercle.

The sixth (rearmost) arises from no visible bone or cartilage, from a point just ventral to the tip of the lower fork of the opercle, and extends up and across the junction of the cleithrum and supra-cleithrum. It is the shortest of all, being only 2 mm. in length. Like the succeeding ones it has a strong bony ridge along one side. and widens at the anterior end into a lacrosse-stick shape.

Branchial Arches

The gills show clearly through the bones of the side of the head. but no detail can be made out as to supporting structures. The gill openings are small, round (.16 mm. in diameter), and open at the vertical of the seventh vertebra.

Vertebral Column

The general direction of the column is a gentle rise headward of about 20° from the horizontal ventral surface of the fish, up to the first vertebra, which makes a sharp dip forward to the foramen mag-

num. Or if we consider the line of the vertebrae as horizontal, then the first vertebra and the head are deflected 40°. The chief characteristic is the great linear height of the neural and haemal arches and their unusually vertical disposition.

There are twenty vertebrae, of which twelve are trunk and eight caudal. The neurapophyses of the anterior vertebrae are wide and tall, forming a triangular arch of bone, very slightly thickened at the summit and ending in a short point. Posteriorly the arches increase considerably in height, but become very narrow, the canals consecutively lessened by the filling in of bony tissue from the apex of the arch. As we approach the tail vertebrae we find a relatively small perforation while each neural spine has lengthened into a sort of wavy, vertical osseous pennant. The most anterior neurapophysis is directed forward, but the succeeding ones are vertical up to the thirteenth or the first caudal, when they acquire a backward slant.

Haemapophyses are wholly lacking on the first two vertebrae, while on the succeeding three they are downward pointing spikes. From the sixth on the haemapophyses duplicate the neural arches, lacking only the extreme length of the spines with their wavy points. The haemal arches of the trunk are more or less vertical, but at the thirteenth vertebra they assume a decided backward slant, more pronounced than that of the neural arches.

Zygapophyses are found on the first to seventh vertebrae in the form of long, slender spines, directed forward and upward, almost touching the central part of the neural arch in front, and of no articular value whatever. On the first vertebra these are provided with wing-like. expansions which articulate with processes from the exoccipitals.

There is no trace of ribs.

Caudal Fin and End of Vertebral Column

The next to the last vertebra has a normal perforated neural and haemal arch, but the spines themselves are prolonged to twice their usual length, and flattened out posteriorly into long, club-shaped expanses, which end respectively at the summit and the base of the fan-shaped tail support. Just above the reduced canals in this penultimate vertebra, two narrow, leaf-shaped projections arise from near the

base of the neural and haemal arches, and extend straight out to the full length of the preceding apophyses.

The last vertebra consists of a normally shaped anterior half-centrum, giving rise to a slightly undulatory urostyle, which lies in high relief along the upper anterior face of the caudal support, reaching half-way to its summit. At the base of the urostyle there is a round perforation from side to side, enclosed by the ascending boundary of the lower part of the basal tail bone.

Although the tail support is well ossified, I can make out no division into epi- or hypurals. This fan shaped bone appears quite homogeneous.

There are nine caudal rays and the only hint of a division of the basal bony support is in the very slightly wider interval between the four upper and the five lower rays. The split bases of all the rays overlap the basal support as much as .4 mm. while the base of the uppermost ray projects even beyond its anterior border. The bases are not stellate like those of the dorsal and anal rays, but end in an elongate, blunt, finger-like projection.

The thick body envelope extends a little beyond half the length of the rays. The uppermost and the two lower are short and extend less than half the total length of the others. These central six are ex-cutaneous and functional, and are equal in length—7.5 mm. over all. The central four are branched at the tips, and all are distally furnished with an expanded, leaf-like, colorless blade of tissue. Counting down from the uppermost long rays the sequence of segmentation is as follows:

2nd ray	8					segments
3rd ray	10	plus	branch	4		"
4th ray	12	"	"	4		"
5th ray	13	"	"	4		"
6th ray	11	"	"	2		"
7th ray	10					

The three outermost short rays have only one or two indistinct segments.

Dorsal Fin

The three rays of the dorsal fin begin far back on the body, four-fifths of the distance from the snout to the tail. The bases of the three

rays arise so close together and so obliquely that, viewed laterally, all are actually between the verticals of the neural spines of the 13th and 14th vertebrae. The base of the third ray rests on the trunk proper, while that of the first is raised obliquely upward so that it is halfway between the body of the fish and the external surface of the cutaneous envelope. There is no hint of bony supports, merely the short, oblique lateral muscle bands. In front, a longer muscle, the levator, extends almost to the tip of the 12th neural spine.

Like all the other fin rays, each of these dorsals arises from two bases, placed laterally well apart. In the first dorsal this width is .32 mm. This bilateral fission persists throughout much of the length of the ray, although a short distance from its proximal end the space becomes filled with transparent tissue. Each ray half is flat, the base is slightly expanded and presents a three-pointed face for the attachment of the muscle.

The direction of the rays is very obliquely backward, almost paralleling the contour of the trunk. They are exceedingly flexible and wavy. Close to the tips of the rays, just before they protrude from the skin each show cross segments, typical of soft fin rays in general. There is only one in the first and longest ray, two segments in the second, and three in the lowermost or third. Distally the rays protrude from the skin, each fine terminal point showing osseous structure, and enveloped in a flat, vertical leaf of clear tissue. The total length of the first ray is 4 mm., of which .7 mm. extends above the outer skin. The tips of the dorsal rays reach almost a millimetre beyond the base of the outer caudal ray.

Anal Fin

The anal fin is identical with the dorsal both in relative longitudinal position, number of elements and in general structure.

Pectoral Girdle and Fin

The shoulder girdle may be taken to begin at the junction of the posttemporal and the supracleithrum. This latter bone is long and slender and curves down and back from the postero-lateral rim of the cranium to midway between the posterior spines of the opercle.

This bone appears to be double, a separate but closely applied element being discernible internal to and hence almost hidden by it. The second is almost as long as the supracleithrum, its upper end projecting not far from the post temporal, and affording a point of attachment for an important lateral bundle of muscles which jut off obliquely from the main vertebral trunk mass. I cannot be certain of its identity if indeed subsequent ossification does not make it an inherent part of the supracleithrum.

At the lower end of the supracleithrum the cleithrum proper bends forward and twists as it bends, curving as a long, thin, slightly flattened rod beneath the ceratohyals and heads of the branchiostegals, to end on the mid-throat, where the very thin, elongated points almost touch. This spot is on a transverse level with the heads of the second pair of branchiostegals.

Behind and a short distance above the lower extremity of the supracleithrum arises the postcleithrum, separated a very short distance from the more dorsal member. It runs down and back and almost surrounds the spherical body cavity, being closely applied to the golden viscera, except for the very short distal tips. It is even more slender than the other bones of the shoulder girdle and is flattened, with a raised linear midrib. Close to the junction of the two anterior girdle bones and internal, a round flat ossification is all that can be made of the scapula.

The total absence of ribs has already been mentioned, and it seems appropriate here to indicate the part which the cleithrum, postcleithrum, and the fifth and sixth branchiostegals play as a partial substitute for ribs in functioning as a visceral suspensorium. A thin but strongly fibred sheet of muscular tissue extends tautly over the body cavity, transversely across the entire length of the postcleithrum, both before and behind, and ending at its tip. Anteriorly this muscle sweeps on until it reaches the cleithrum, and ends in a long attachment to that bone. On its way it includes a large extent of the elongated fifth and sixth branchiostegals, passing over and attached to them. The other four branchiostegals are on a higher level and quite free.

The pectoral fin is composed of seventeen well ossified rays, the sixth from the bottom being the longest, 1.7 mm. in length.

These are arranged along the curved top of the pectoral "palm" over an arc of about one-third of a circle. The five longest have four

segmentations each, while dorsally and ventrally these are reduced in succession to three, two and one, the outer three rays possessing no cross segments. The free tips of the rays show enlarged leaves of hyaline membrane. The pectoral fins are really functional, for they project well above the cutaneous envelope, the rays and body of the limb to well below the attachment of the outermost ray being free.

The greatest length of the sub-ray part of the pectoral, from the center of the ray base to the cleithrum junction is 2.4 mm. The "palm" width from the first to the seventeenth ray base is 1.6 mm. as compared with .5 mm. at the narrowest part of the "wrist." The only trace of ossification of the brachials is a fairly well outlined, small, superior radial.

The split base of the rays is reflected in the entire musculature of the pectoral member. The anterior row of struts is supported by a stout muscle sheet attached along the external face of the junction of the supracleithrum and cleithrum, extending some distance along each bone. The posterior ray bases are controlled by a smaller band of muscle finding its proximal attachment along the corresponding area of the postcleithrum. From base to ray base these two muscle areas are well separated, it being possible to look clearly down between them.

Body Cavity and Viscera

The coelomic cavity is spherical and is partly enclosed and wholly supported by the long, slender postcleithra and cleithra. Its posterior boundary is at the vertical of the ninth vertebra. The anterior half of this region is almost homogeneous, orange, and yolk-like in appearance. The folds of the intestine occupy the posterior hemisphere.

The anus is asymmetrical as noted by Brauer, but not mentioned by Regan for *mollis*. It is 1.6 mm. to the left of the mid-line, and slightly in advance of the anterior origin of the anal fin. The anus is 4.3 mm. from the caudal fin, thus being three-fourths of the body distance from the snout. This position is at the vertical between the twelfth and thirteenth vertebrae, thus marking exactly the division between trunk and caudal portions of the body. From the anus the colorless intestine winds forward and inward, reaching the midline 2.7 mm. in front of the anus, and entering the visceral area between the tips of the slender, incurved postcleithra. Little can be distinguished

of intestinal detail, except some large rounded glands which appear to line the compressed stomach.

ILLICIUM

The tentacle bulbs are two in number, side by side, close together, colorless, pear-shaped, projecting clear of the surface (.16 mm.) of the epidermis, their bases sunk in a common depression. Their position, viewed laterally, is above the center of the nostrils. Just beneath the skin they unite in a single vertical, colorless stalk, which immediately joins the upright illicium stem. This is an ossified, very thin, slightly flattened needle bone, .37 mm. in length, slanted forward at an angle of 45° with the vertebral axis. It is attached by its delicate base to the top of the expanded anterior tip of the basal bone support. This latter is 2.1 mm. in total length, extending slightly forward of the illicium stem attachment, and backward in a depression of the cranium.

Some distance back, along the top of the horizontal basal bone, a tiny ossified sliver stands upright, possibly a vestige of what in *Lophius* is the second illicial tentacle. The origin of this basal spine is at the center of the supraoccipital and this is its only point of attachment. It has a decided upward slope and no connection anteriorly with the ethmoid or other cartilages.

The musculature of the basal bone of the illicium is surprisingly complex. To take only the more evident muscles, one pair extends from the expanded anterior end back to the mid-parietals, its fibres raised well above the level of the frontals. A second originates near the posterior end of the basal bone on the supraoccipital and runs obliquely forward to the inner anterior spine of the frontal, while a third pair begins just behind the expanded anterior head of the basal rod at about the place of origin of the second tentacular vestige, and runs obliquely forward and outward, over the body of the frontal to the external frontal spine. At least two pairs of tiny muscles control the short, vertical illicium stem, all of course being imbedded in the cuticular envelope.

NOSTRILS

These are very large and conspicuous but not nearly as exaggerated as the corresponding organs of *Rhynchoceratias* or of *Aceratias*

macrorhinus. Viewed from above, the nostrils are seen to be well separated (1.2 mm. interval), only slightly elevated above the cutaneous envelope, and half way between the eye and the snout. Laterally they appear pear-shaped, the large end resting close to the lachrymal vestige, and about as deep as the eye diameter. There is a large, round anterior opening, and a second, oval, higher up and obliquely backward facing the eyes. Seven folds of olfactory laminae are visible, one upon the other.

Eyes

The eyes are relatively large for the size of the head, occupying one-fourth of the total distance from the snout to the base of the pectoral (junction of the supracleithra and cleithra). The eyeball is round and quite lacking in black, reflecting tissue, being of a homogeneous, pale yellow brown after clearing. Its normal position shows a 24° ocular angle downward, and 18° of divergence forward. From directly overhead, only a fifth of their diameter is concealed by the curved edges of the sphenotic and frontals, while the orbit of the cutaneous envelope almost exactly bisects the eyeball. They are in no sense telescopic or monocular in vision.

Fig. 6. *Notostomus beebei* Boone sp nov. Type · Nearly natural size Photograph by Julius Kirschner.

NOTOSTOMUS BEEBEI

A New Species of Deep-Sea Macruran from Bermuda.[1]

BY LEE BOONE

Preamble—Genus *NOTOSTOMUS*,[2] A. Milne Edwards.

(Fig. 6)

Strikingly conspicuous among the thousands of bathypelagic macruran crustaceans obtained by the twelfth Expedition of the Tropical Research Station of the New York Zoological Society to Bermuda, under the direction of Dr. William Beebe, is a new species, ***Notostomus beebei,*** represented by a magnificent spectrum-red animal quite six inches long. In the light of present knowledge this genus is to be regarded as one of the rarest of deep-sea Macrura, since only thirty-four specimens representing eighteen distinct species have been captured by all the deep-sea expeditions prior to the Beebe-Bermuda dredgings. Of these, nineteen individuals were taken in the north Atlantic by the *Michael Sars.* Murray and Hjort (See "Depths of the Ocean," 1912, p. 386, fig. 425) state that five species, four of which are new, are represented. It is to be regretted that diagnoses of these new species have not yet been recorded.

Notostomus beebei is the fifteenth species of the genus to be described and the nineteenth member to be recorded, unless it prove identical with one of the undescribed new species mentioned by Murray and Hjort, in which event *N. beebei* becomes the eighteenth member. The specimen before me measures 141 mm. or about 5.5 inches from tip of rostrum to tip of telson, making it among the largest known specimens of the genus. It is the seventh species to be described from the deep-sea fauna of the Eastern coasts of the Americas, *N. gibbosus* A. Milne Edwards, originally taken by the Blake off Grenada, Antilles, in 627 fms. being the genotype. *N. elegans* M. Edw. was taken in the Gulf of Mexico, 955 fms., by the Blake. *N. brevirostus* Spence Bate, said by him to be a near relation of variety of *N. gibbosus* M. Edw., was taken by the Challenger off Pernambuco, Brazil, Stanley Kemp considers this identical with Bate's *N. perlatus*

[1] This paper properly should have been delayed until the trawling data of the Bermuda Oceanographic Expedition was published, but as the description was completed at an early date it has been thought best to bring it out at once. The exact locality of the capture of the new species was 32° 16′ No. Lat.; 64° 36′ West Long., five miles south of Nonsuch Island, Bermuda, at a depth of nine hundred fathoms. Ed.

[2] Contribution, New York Zoological Society, Department of Tropical Research, No. 318.

also taken by the Challenger near the Philippine Islands. Bate himself indicated his awareness of this close relationship, noting both *perlatus* and *brevirostus* as varietal differences from *N. gibbosus.*

N. robustus Smith, 1884, was taken by the Albatross off the east coast of the United States and *N. vescus* Smith 1886, also off the east coast of the United States, by the Albatross, in 2949 fms.

N. murrayi Bate was taken in the southern Atlantic near Tristan da Cuhna, in 1900 fms. by the Challenger, while *N. atlanticus* Lenz, 1914, taken in 1640 fms., west of the Azores, completes the list of described species known from the entire Atlantic.

Two species are known from the tropical American Pacific, of which *N. westergreni* Faxon, 1895, the type was taken by the Albatross off the coast of Ecuador in 1740 fms. The second record of the species was a specimen taken off the Cape of Good Hope in 800 fms.; the first female of this species was taken by the Arcturus at station 74, in 900 fms.

The second species from the tropical American Pacific is *N. fragilis* Faxon, 1895, taken off Cocos Island in 700 fms.

The other three described species of *Notostomus* were taken by the Challenger and described by Bate. One of these, the above mentioned *perlatus,* was taken near the Philippines in 2150 fms. and by the Percy Sladen Trust Expedition south of the Chagos Archipelago in 1200 fms. while *N. patentissimus* Bate was taken in 2150 fms., south of the Philippines, and *N. japonicus* Bate was taken in only 565 fms., south of Japan, the least depth at which a *Notostomus* has been recorded.

N. gibbosus A. Milne Edwards, was also taken by the Beebe Expedition at 1000 fms.,—net 192, June 19, 1929, a single specimen, spectrum red, which curiously measures from tip of rostrum to tip of telson, 141 mm., or exactly the same as does the new species. The eye in *N. gibbosus* is substantially larger than in *N. beebei,* the cornea of the former measuring 5.1 mm. long diameter, while that of *N. beebei* measures 3.8. The rostral formula is also different and the rostral shape is likewise distinctive. In fact the rostral shape and formula of *N. beebei* is strikingly different from that of any of the known members of the genus.

The present specimen of *N. gibbosus* curiously possesses the unbroken rostral-orbital carina of *N. gibbosus* on one side of the carapace, while the opposite side has this carina interrupted behind the orbit and directed obliquely upward as in *N. robustus* S. I. Smith. It is highly probable that capture of additional specimens will prove these two species

identical. Prof. Smith's description of the species is much more satisfactory than that of Dr. Milne Edwards.

NOTOSTOMUS BEEBEI, sp. nov.

Type: Locality, five miles south of Nonsuch Island, Bermuda, Lat. 32° 16′ N., Long. 64° 36′ W., May 25, 1929. Taken in net 124 at a depth of 900 fathoms. Type in the collections of the Department of Tropical Research of the New York Zoological Society, Field No. 29213.

Technical Description: Rostrum about 20.5 mm. from tip to orbital angle; carapace 45.0 mm. from orbital angle to posterior margin, abdominal segments one to six inclusive 54 mm. long, telson 25 mm. long. Carapace robust, compressed in the median dorsal line forming a strong carina which is moderately convex forming a sort of crest, which is more elevated anteriorly, terminating about opposite the orbital angle, and which is regularly, very finely denticulated throughout its entire length. There is a concave, non-denticulated excavation interrupting the dorsal carina, beginning about opposite the orbital angle and terminating distally about opposite the distal margin of the basal antennular segment. The dorsal margin of the rostrum anterior to this excavation is compressed, carinate, armed with a compound quadrispine fused basally, at the margin of the dorsal excavation and followed anteriorly by seven subequal and subequally spaced small, sharp, upward and forward directed spines, which are spaced along the down sloping rostral carina. Beyond the most anterior of these spinelets is the long, acute forward pointing apical spine which is 5.0 mm. long. The inferior rostral margin is armed with three short, acute, obliquely downward-pointing spines, spaced subequally, the most anterior of which is opposite the first spine of the superior margin. There is a carina on each side, converging anteriorly in the apical spine of the rostrum and running back along the inferior rostral margin to a point just behind the orbital angle, and terminating slightly above, but not fusing with the orbital carina which begins about 2 mm. behind the frontal margin and extends back quite to the carinated posterior margin of the carapace, having a length of 45 mm. Below this carina and separated from it by a distinct sulcus there is on the hinder half of the carapace a shorter carina about 18 mm. long approximately paralleling the orbital carina. There is a short, wide, postorbital spine. The antennal spine is longer and flares outward obliquely. The antennal

or second lateral carina runs from this spine backward, uniting with the carina of the extreme lateral margin posteriorly, where the latter converges with the carinate posterior margin of the carapace. Anteriorly this lateral carina curves around along the frontal margin, having its origin in front of the antennal spine. There is a short slightly oblique hepatic carina uniting the orbital and antennal carina.

All six abdominal segments are carinate in the median dorsal line, this carina terminating on each third, fourth, fifth, and sixth, segments in a small, sharp spine, directed posteriorly. The telson has a deep excavated sulcus throughout its entire length. The caudal fan has the inner blade narrowly oval, tapered and shorter than the telson. The outer blade is much wider, broadly oval distally and rounded, with a subdistal spine on the outer lateral margin and is longer than the telson.

The eye has the stalk smaller basally, dilating distally but less so than the terminally placed, ovoid cornea, which is shining black.

The antennulae have the basal article excavate beneath the eye and with a spine distally on the raised outer lateral margin: the second and third articles are short, chunky, the distal margin of the second joint recurvate in a lateral view; the inner flagellum is exceedingly slender, and after the first thirty annulations is very finely articulated, having a length of 70 mm. The outer whip is very thick for the first 15 mm. of its length; it is broken off in the type at a length of 35 mm.

The antennae have a short thick basal article, with a spine at the outer distal angle, the second and third articles are stocky, their combined length about two-fifths of that of the scaphocerite, the flagellum is 10 inches long, smooth and fine. The scaphocerite exceeds the length of the rostrum by about 20 per cent. of its own length. It is oval, with its greatest width about two-fifths of its length; the inner lateral margin more convex than the outer, which is thickened and produced distally in an acute spine which projects beyond the narrowed, rounded margin of the carina. There is also a median longitudinal carina on the scale.

The legs and pleopoda afford no specific characters.

The illustration of the species was made by Mr. Julius Kirschner of the American Museum of Natural History under my direction.

NEW DECAPOD AND ISOPOD CRUSTACEANS FROM GONAVE BAY, HAITI[1]

BY LEE BOONE

INTRODUCTION

(Figs. 7, 8, 9, 10)

Preliminary survey of the extensive collection of Crustacea, obtained in exploration of Gonave Bay, Haiti, conducted by the Tenth Expedition of the Department of Tropical Research of the New York Zoological Society, under the direction of Dr. William Beebe, has resulted in the classification of nearly a hundred species, chiefly Decapoda, including many rare West Indian species, in large series. Among those are a new species of spider crab, *Teleophrys beebei,* a new sponge-dwelling marine shrimp, *Corallocaris perlatus,* and a remarkably exquisite new marine Isopod, *Paracerceis edithae,* of which diagnoses with illustrations are herewith presented. Full report of the Crustacea, which involves approximately a five hundred percentum increase of the known Haitian fauna, will be issued later.

I am indebted to Dr. William Beebe for the privilege of preparing this paper and to his artist, Mrs. Edith Thane, for preparation of the illustration of the isopod, and to Mrs. Helen Ziska, for the drawings of the crab and shrimp.

[1] Contribution, New York Zoological Society, Department of Tropical Research, No. 319.

Teleophrys beebei sp. nov.

(Fig. 7)

Type: Field No. 2749, an ovigerous female, was taken from Lamentin, Gonave Bay, Haiti, and is deposited in collections of the Department of Tropical Research of the New York Zoological Society.

Material Examined: Type and female paratype from corals a fathom deep, from Lamentin Reef,.Haiti.

Distribution: Restricted to the type locality.

Name: This remarkable little species is named in honor of the leader of the expedition, Dr. William Beebe.

Diagnostic Characters: Carapace longer than broad; no marginal spines, dorsal surface broken into a series of lobes. Merus of ambulatories broadly cristate, suboval, margins unbroken, dorsal surface deeply pitted.

Color: (Recently preserved formalin specimen) Vivid carmine, maculated with large white areas, two on the gastric areas anteriorly branching narrowly forward to the orbital margin, separated by a median red area, posterior to which they are united by a white band across the mesogastric region, and continuing posteriorly as wide white areas on each side of the cardio-intestinal region and

diverging out to the posterolateral margin. A similar large white area occurs midway the high lateral wall of the carapace, and is repeated on the proximal parts of the meral joints of the first and second ambulatory legs, which lie below and adjacent to this white area of the sidewall of the carapace. The lateral and distal margins of the merus, the distal part of the propodus, and the proximal and distal parts of the dactyl, of the ambulatory legs are maculated with white.

Habits: This quaint little crab makes its home in the crevices of the shallow water corals. The sculpturation and color pattern of its carapace render it more like a fragment of coral than a crab and its remarkably developed toes are especially modified for living in this type of environment.

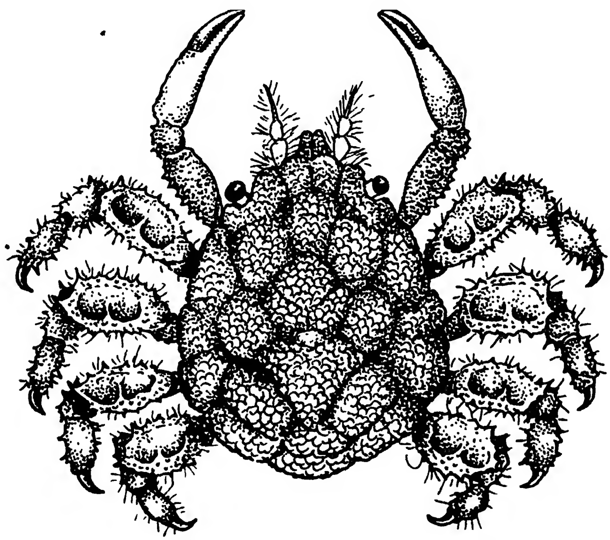


Fig. 7. *Teleophrys cebei* sp nov. Type × 5. Drawn by Helen Ziska.

Technical Description: Carapace broadly pyriform, longer than wide, 8 mm. long from tip of rostrum to posterior margin, 6.4 mm. maximum width, across the branchio-cardiac region; entire surface paved with rather coarse, elevated, rounded granules. Region of the carapace sharply defined; carapace broken into numerous swollen lobes. Rostral horns extending not quite as far forward as the second joint of the antennae, triangulate, with the lateral margins rendered denticulate by the large granules; interrostral sinus linear. The superior and outer orbital margins are entire; the superior orbital border is swollen forming a large rounded lobe which is circumscribed by a linear sulcus. A short median longitudinal sulcus extends back a short distance from the base of the rostrum, the area on either side of this sulcus being an elevated linear series of rounded, spinose granules. The mesogastric region is swollen, and is especially elevated on each side where the white areas are confluent with the median red area; the mesogastric

region is rounded; behind this the cardiac region forms a rounded subtriangular lobe with the apex directed posteriorly; and followed posteriorly by two smaller rounded lobes, side by side, which emphasize the intestinal region. The branchial region is divided into three lobes, two being along the lateral margin; the third being a longer lobe, along the posterolateral margin; separated from this lobe by a deep diagonal sulcus there is a fourth, elongate lobe on the inner branchial region and separated from the cardiac lobe by the deep sulcus which circumscribes the latter. The sidewalls of the carapace are deep on the posterior and median parts, gradually tapering anteriorly. It is covered by the same type of granules as the dorsal surface and bears an irregular depression chiefly in the large white spot. The female abdominal belt is sub-circular, seven-segmented; the lateral margins of the belt being heavily fringed with long white setae. In the ovigerous type specimen the outer distal branches are long, slender, heavily fringed with setae, and curved, one above the other, around the outer margin of the brood-pouch, increasing its depth, basket fashion.

The internal antennae are stocky and fold upon themselves longitudinally within the fossett which lies beneath the rostrum.

The external antennae have the proximal joint enlarged, granulose, and produced to a rather broad bluntish triangular tooth; the second joint arises from an excavation in the inner distal border of the first joint, and is somewhat dilated distally, extending a short distance beyond the tip of the rostral horns; the third joint is much smaller than the second, the flagellum is very slender, consisting of five or six small, linear joints which are heavily fringed with long setae.

The external maxillipeds are typical of the genus; the ischium is nearly twice as long as wide, with its proximal border diagonal; its lateral margins subparallel, the inner distal angle produced into a roundish lobe; the merus is approximately as high as its greatest width, which later exceeds the width of the ischium; the inner distal angle of the merus is excavate for the reception of the three-jointed palp.

The chelipeds (female) are slender and when folded, the carpal joint projects but a short distance beyond the rostrum. The basal joints are strong, the ischium is stocky, produced to a stout triangular point on the inner distal ventral-angle reinforcing the union with the merus; the merus is long, narrow, roughly trigonal with the dorsal surface rough with coarse granules; the carpus is short, convex and granular on the outer surface; the propodus is long and slender, about one and one-half times the length of the merus; the outer face of the propodus is granulose proximally, but smooth and gently rounded for the remainder of the length; the fingers are long, slender, comprising approximately two-fifths of the length of the propodus; the inner cutting edge of each finger is crenulated into seven or eight teeth; the distal end is rounded, spoon-shaped and finely crenulated.

The ambulatory legs present the most striking characteristic of the species; they are subequal, slightly decreasing in length from the first to the fourth pairs in the order named. The proximal joints are short and close-set; the merus of this species is the most remarkably cristate of any member of the genus. The central or main portion of the merus is raised and roughly granulose; the anterior lateral margin is produced into a wide, convex, marginal laminate process which

increases in width distally and bears on the dorsal surface along its line of union with the main part of the merus a series of two deep subcircular pits; the posterior lateral margin of the merus is even more widely produced, forming a flaring rounded plate which is especially produced at the distal border; this plate is deeply concave on its dorsal surface and bears two deep circular pits near its fusion with the central part of the merus; the carpus is large, with the dorsal surface rough and granulose and the lateral margins cristate; the propodus is no longer than the carpus but is much narrower, trigonal, with the two upper surfaces rough; the outer distal part of the propodus is produced into a rounded tapering process which projects outside the dactyl, reinforcing this joint; the dactyl is stout, curved, tapering to a sharp curved point and armed on the concave lateral margin with a series of six or seven serrulate teeth.

The lateral margins of the ambulatories and in a less degree their dorsal surfaces, are furnished with long plumose setae.

Corallocaris perlatus sp. nov.

(Fig. 8)

Type: Field No. 2728, an adult male and ovigerous female, also three ovigerous females and one male, Field No. 2716, Gonave Bay, Haiti, and are deposited in collections of the Department of Tropical Research of the New York Zoological Society.

Distribution: So far known only from the above cited stations in Gonave Bay, Haiti, as dwellers in sponges; the specimens taken appear to live a pair each in an isolated cavity of the sponge.

Name: The name refers to the beaded great chelipeds.

Technical Description: Animal slightly smaller than the average-size snapping shrimp, which it superficially resembles. Color in recently preserved formalined specimens opaque creamy. Great chela of the male exceeding in size the carapace; in the female nearly as long as carapace. Rostrum fully one-half as long as the remainder of the carapace, the tip of the apical spine projecting slightly beyond the distal margin of the third peduncular article of the antennae. The rostrum is laterally compressed, slightly arched proximally between the orbits and with the distal portion slightly curved downward, the apical spine directed straight forward. The superior margin is armed with eight to ten spines, including the apical spines. These spines are smaller proximally, increasing in length distally, the first spine being quite rudimentary, the fourth to eighth spines as a rule long, subequal, while the ninth and tenth spines are subequal, but a trifle shorter than those immediately preceding. All the rostral spines are acute, directed obliquely forward, the distal group forming a fan-like crest; the longer spines are of greater length than the width of the adjacent rostrum, in this respect differing decidedly from both *C. atlantica* Rathbun and *C. wilsoni* Hay and Shore. The rostrum arises from a thickened base in the extreme anterior portion of the carapace. The carapace is glabrous, rather soft, moderately compressed, armed with a strong, acute postorbital spine, directed forward and outward and slightly exceeding the

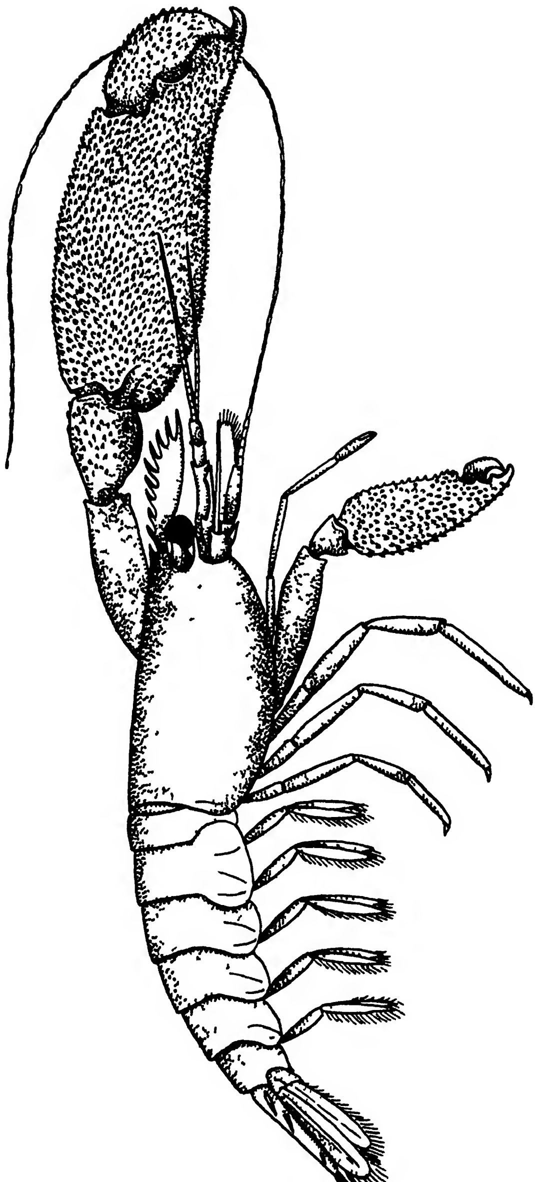


Fig. 8 *Corallocaris perlatus* Boone Male, type × 3 Drawn by Helen Ziska

length of the eyestalk. The antennulae have the basal article narrow, slightly concave on the upper surface, a little longer than the eye and with a spine at the outer distal angle; the second and third articles are short, cylindrical, subequal, reaching almost but not quite as far distally as do the rostrum and scaphocerite; the flagellum is biramose, the outer whip being shorter and much the thicker, itself bifurcating after the ninth thick article, the inner branches being the shorter and consisting of only seven small articles which have a horny brush of long fine setae; these setae are more sparsely spaced along the under side of the peduncle; the longer branch consists of about fourteen articles and is devoid of setae. The longer, slenderer whip which arises from the third peduncular article is about one and two-fifths times the length of the thicker inner branch, and does not bifurcate distally.

The eyes are large, the stalk stocky extending about as far as the third rostral spine; the cornea two-thirds as long as the stalk, spherical, terminate, black.

The antennae have the proximal joints short, the carpocerite slender, cylindrical, reaching as far forward as does the third peduncular article of the antennae; the flagellum slender, devoid of setae, consisting of approximately forty annulations and being about one and two-thirds times as long as the longest whip of the antennulae.

The abdomen is moderately compressed in the male, broader in the female, if extended not quite twice as long as the carapace, exclusive of rostrum. The epimeral plates of the first, second, and third plates are produced and broadly rounded, forming a capacious brood pouch in the female, the epimera of the fourth and fifth segments are less prominent but have the postlateral angle produced and rounded. The telson is almost twice as long as the sixth segment and is decidedly tapered, with the proximal width nearly twice that of the distal width. The terminal margin is evenly rounded and armed with four articulated spines, a slender submedian pair and an equally long but much thicker outer pair, one each at the outer lateral angle. In addition to these, there are three pairs of long, acute articulated spines on the dorsal surface, one pair near the base of the telson the second pair roughly one-third of the length from the base, and the third pair, approximately three-fourths of the length from the base. The caudal fan has a small peduncle, a broadly oval, cilated inner blade which extends the length of the telson a distance approximately equal to the length of the distal articulated spines of the telsonic margin. The outer blade is wider distally but a trifle shorter than the inner blade and with the distal margin more bluntly rounded, and a stocky acute subdistal spine at the outer lateral angle.

The first legs are extremely slender, almost linear, and very long, with the ischial and meral joints greatly elongated, the carpus two-thirds as long as the merus, the propodus about three-fifths as long as the carpus, of no greater diameter, weakly chelate, the fingers subequal, nearly straight, almost one-third of the total propodal length.

The second legs are conspicuously unequal in both sexes. The left one is normally the larger; in the male type it is approximately of as great size as the body appears with the telson bent under the body. In the female the unequality

is conspicuous but the great chela is only two-thirds the size of that of the associated male, while the body of the female is much stouter than that of the male. The male great cheliped has the merus compressed cylindrical when extended reaching beyond the body of the animal to about midway the rostrum, the carpus short, convex, narrowed proximally, dilated distally, the under surface produced to a narrowed ridge which terminates distally in a sharp tooth, the lower distal face excavate fitting upon the rounded end of the huge propodus. The propodus is very large, convex proximally, thick and high, cylindrical, more laterally compressed distally near the base of the finger but still quite thick, the propodal finger bent inward with the tip slightly upward curved and projecting beyond the tip of the hinged finger, the propodal finger has visible from the inner and outer faces a small triangulate subbasal tooth immediately beyond which it is concavely excavate for the reception of the huge blunt tooth of the hinged finger. The hinged finger is high, laminate with its curved triangulate tip closing inside the propodal finger, a short distance from the base of the latter. There is one large truncated tooth. The entire surfaces of the propodus, the propodal finger and the proximal part of the hinged finger are covered with numerous, short, conical, sharp spinose granules. These are visible to the unaided eye and form a conspicuous field-character. On the under side of the proximal part of the propodus these spines are arranged in regular transverse rows, giving them a brocaded or slightly corrugated appearance. The propodus and small cheliped of the male is by actual measurement two-fifths as long as that of the large one, but this measurement gives no true idea of actual disparity between the two, because the palm of the great chela is enormously dilated while that of the small cheliped is much less so, having a more laterally compressed aspect especially on the distal half of the palm and the fingers, which are slightly incurved; the fingers are short, subequal; almost the entire cutting edge of the upper finger forming a convex lobe which is separated from the acute finger tip and fits into the concavity of the lower finger, the tip of the latter closing between this convex lobe and the apex of the upper finger. The entire surface of the small cheliped is covered with spiny granules, as in the larger cheliped.

The third, fourth and fifth legs are similar in structure, successively decreasing in size and length in the order named. Each has the merus elongated and rather wide; the carpus only half so long and narrower, the propodus three-quarters as long as the merus, laterally compressed, tapering a little distally; the dactyl extremely short, rudimentâry, curved, acute, its length scarcely greater than the width of the adjacent propodus.

The female type is carrying about 300-600 round, yellow eggs.

Remarks: The different rostral dentition of this species at once separates it from the other West Indian species, *C. atlantica* Rathbun 1901, which has only four rostral teeth in addition to the apical teeth. This was described from two small specimens, taken at "Fish Hawk" station 6079, off St. Thomas in 20-23 fms.

It is likewise distinguished from *C. wilsoni* Hay and Shore 1918, by the greater length of the rostrum, with a lesser number of teeth, which are differently arranged forming a fan-like crest in *C. perlatus;* the second chelae of *C. perlatus* are beaded with conical spines all over, while those of *C. wilsoni* are glabrous.

ALPHEUS PLATYCHEIRUS Boone

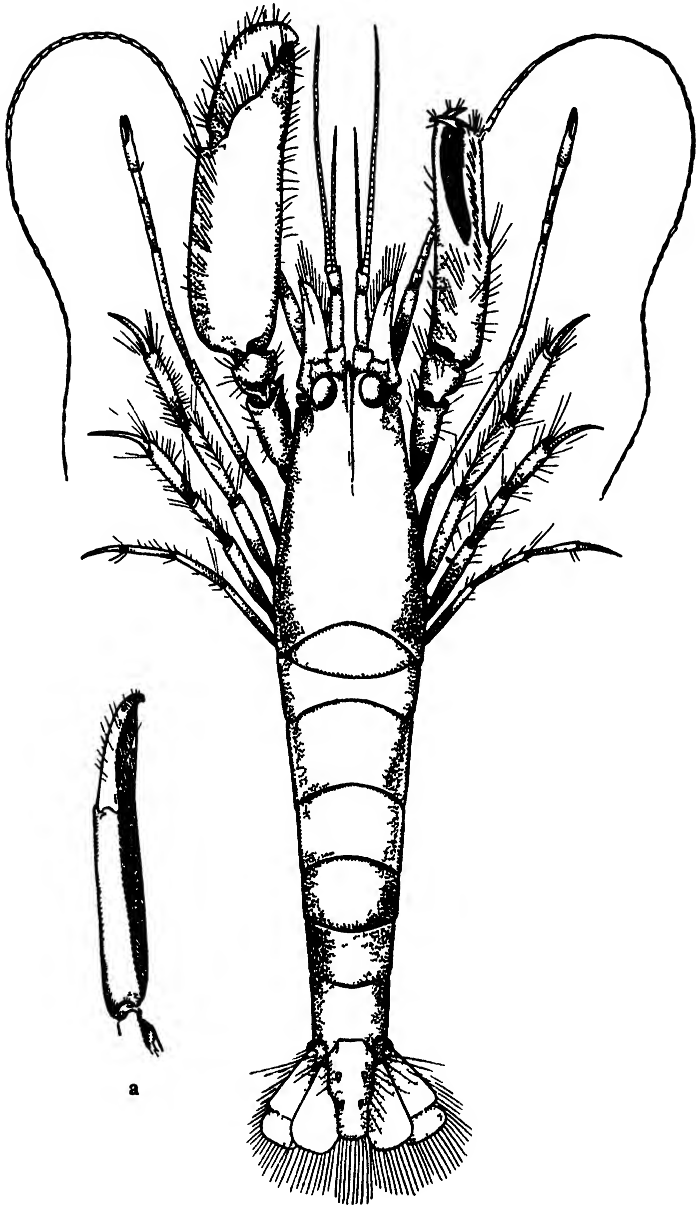
(Figs. 9 and 9a)

Type: The type was taken in 12 fathoms at Siguanea Bay, Isle of Pines by the Pawnee and is deposited in the collections of the Peabody Museum, Yale University.

Material Examined: A male and a female, from a loggerhead sponge, Port-au-Prince Bay, No. 2767, Haiti. One mutilated specimen from a fish stomach, captured in the same locality. The type was unfortunately badly mutilated in the dredge, hence the capture of three specimens, including both sexes, by Dr. Beebe, is a very welcome and important find. This species, with its exceedingly flat claw is one of the most peculiar of the sponge-dwelling shrimp.

Technical description: Animal compact, body subcylindrical, great cheliped extremely flat. Rostral tooth acute, spine-like, projecting beyond the ocular lobe and continuous posteriorly as a distinct carina for two-fifths of the length of the carapace and terminating posteriorly in a median tooth. Ocular lobes prominent, rounded anteriorly and elevated as hemiovoids dorsally, pigment strong, blackish. Carapace smooth, laterally compressed, 9 mm. long or about three-fourths the length of the great cheliped. Abdomen compressed, tapering, the second, third, fourth and sixth segments subequal, the first and fifth segments each slightly shorter than the others. The epimera are but little produced, the pleopoda long and heavily fringed. The first epimera are narrow and overlapped by the second which are moderately rounded, angulated at the posterolateral angle. The third, fourth and fifth segments are similarly produced posteriorly. The telson is one and two-fifths times as long as the sixth segment, narrow, the distal margin rounded and the lateral margin sinuate with a distinct curve about midway its length. There is a median longitudinal depression on the dorsal surface of the carapace; also two pairs of submedian articulated spines. The inner blade of the uropoda is oval, three-fifths as wide as the outer with a conspicuous median longitudinal carina from which there branches midway and almost at right angles, a short carina that reaches to the inner lateral margin. The wider outer blade has a transverse articulation separating the distal fourth of the blade from the proximal part which bears a definite longitudinal carina the greater part of its length. The transverse segmentation terminates in a distinct notch on the outer lateral margin.

The great cheliped has the propodus one-third longer than the carapace, the merus is strongly compressed laterally, a series of spinules along the inferior inner lateral margin; the carpus is short, cup-like, convex on the upper surface, the propodus is one-third longer than the carapace and extremely flat. The anterior lateral face is one-third as high in the median region as its total length; the dorsal and ventral margins are convergent proximally; the propodal finger is a continuation of this flat surface of the palm, but is very lightly depressed in the median area; the finger is long, tapering at the acuminate, upcurved point; on the proximal half of the cutting edge there is a large, suboval tooth which is deeply concave in the center; the distal third of the inner lateral margin of the tooth is



a

Fig 9 *Alpheus platycheirus* Boone × 3 Fig 9a. Dorsolateral view of palm of great cheliped of same Drawn by Helen Ziska

lower than the remaining margin; the distal half of the cutting edge is a narrow grooved edge, which like the tip, is of a different color in the specimen from the remainder of the dactyl; the upper finger is similar to the lower one in length and in being laterally compressed, but differs in that it does not narrow distally; the cutting edge bears a sub-basal elliptical tooth, flat on the upper surface and fitting into the concavity of the opposing tooth of the propodal finger; the tooth of the upper finger is continuous distally with the stout, carinate, cutting edge of the distal half of the finger, which terminates in a slightly curved, rounded tip. The entire propodus, but especially on the dorsal and ventral edges and the distal half of the fingers, is set with unusually long, abundant setae. The small cheliped resembles the larger in general structure and in being strongly compressed laterally. It is shorter by about one-fourth of the length of the dactyl of the larger cheliped and it is only one-half as high as the large chela; the finger of the small chela is one and three-fifths times as long as the related palm, very slender, the cutting face flat, the tip tapering and curved, crossing upon the tip of the similar but slightly slenderer upper finger. There is a decided gape between the fingers which is equal in its median width to that of one finger, and is filled with a dense brush of long thick setae.

The second legs are very slender, the ischium greatly elongated, slightly exceeding the merus in length; the carpus is composed of five joints, of which the second is the longest, the first joint being four-fifths as long as the second; the third, fourth and fifth articles are subequal, each being one-half as long as the first article; the palm of the propodus is two-thirds as long as the distal carpal article and no thicker; the fingers are as long as the last carpal joint and very slender.

The third, fourth and fifth pairs of legs are moderately robust, of the proportions shown in the figure; the dactyli being notably curved, hook-like.

Synonymy: *Alpheus platycheirus* Boone, Bull. Bingham Oceanog. Coll. vol. 1, art. 2, p. 131, fig. 29, and fig. 30, 1927.

PARACERCEIS EDITHAE sp. nov.

(Fig. 10)

Type: The type and nine paratypes, including both sexes were collected at Gonave Bay, Haiti, and are deposited in collections of the Department of Tropical Research of the New York Zoological Society, Field No. 27240.

Distribution: Gonave Bay, Haiti.

Name: This exquisite isopod has been named for the artist, Mrs. Edith Thane.

Technical Description: Body about 5 mm. long in median line; decidedly convex from side to side. Head approximately three-fifths as long as its median width, with the frontal border rounded, produced to a median point and the posterolateral angles produced and entirely occupied by the large oval convex, composite eyes. The inner antennae are nearly as long as the outer pair, extending to nearly midway the epimeral margin of the second thoracic segment, while the

outer antennae extend to the posterior angle of the epimeral margin of the same segment.

The upper antennae are about five-sixths as long as the lower and consist of a long thick basal article, followed by a shorter thick article and a long slender

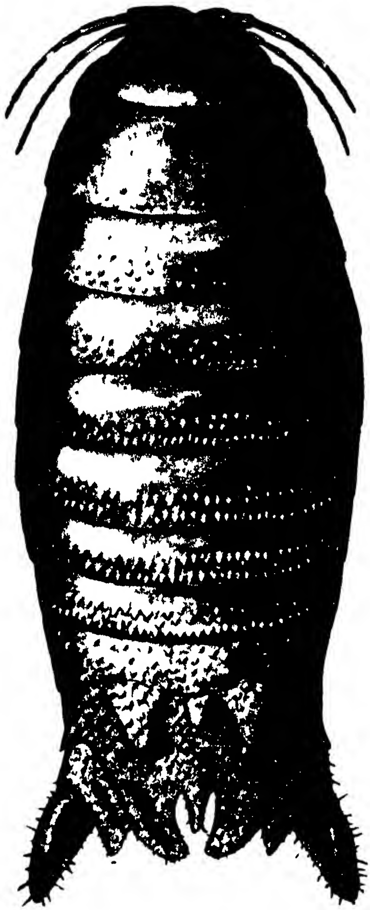


Fig. 10. Paracerceis edithae sp. nov. Type greatly enlarged. Drawn by Edith Thane.

third article, and flagellum composed of six small articles the distal two or three of which are set with tufts of setae on the distal upper margin.

The antennae have the three peduncular articles slender, elongate, the first subequal, the third a little longer, and a flagellum composed of ten fine tapering articles, the distal five or six of which are set with setae on their respective distal margins.

The first thoracic segment is a trifle longer than any of the others which are subequal. The anterolateral angles of the first segment are produced forward in acute processes which extend beneath the eyes to almost the anterior margin of the latter, the postlateral angles of this segment are similarly produced into acute processes which project backward to midway the epimeral margin of the second segment. The epimera of the second to the seventh segments inclusive are narrowed, curved, posteriorly directed with the angles rounded; the epimera of the fifth and sixth segments are more broadly rounded, that of the sixth segment being somewhat flaring and angulated, the epimera of the seventh segment is less protruding than that of the sixth and is widely rounded.

The abdomen consists of two segments; the proximal one is only two-thirds as long in the median line as the last thoracic segment but distinctly wider, the lateral region projects decidedly beyond that of the last thoracic segment and is produced posteriorly and widely, shallowly rounded. The distal segment has the anterior part moderately convex and produced on each side in the median lateral region into a very prominent large conical lobe; between these two lobes there is a smaller but well-developed conical subacute median tubercle; behind this tubercled area the distal part of the segment is produced into three processes, i e., a median tooth which is slender, triangular, tapering, with the upper surface and base slightly convex, and the tip imperceptibly upcurved, on either side of this median tooth there is a subcrescentic sinus, narrowed inwardly and widened distally, and separating the median tooth from the larger paired, submedian processes. Each of these submedian processes has the inner lateral margin concave, the outer lateral margin convex and denticulate, while the distal margin is notched by a wide V. The fixed immovable branch of the uropoda is small with the distal margin rounded and extends less than half the length of the terminal abdominal segment; the movable outer branch is long, tapering, acuminate, flaring outward a little and strongly upcurved. There is a distinct row of microscopic granules across the posterior margin of the second, third and fourth thoracic segments On the posterior margins the fifth segment bears two transverse rows of tubercles, one on the posterior margin and one just anterior to the posterior margin; the sixth segment bears two transverse rows of granules similar to those on the fifth segment, except that the granules are much stronger; the seventh thoracic segment also has two similar rows of granules, which are much stronger than those of the sixth segment; the posterior margin of the proximal abdominal segment is also very granulose; the distal abdominal segment has the paired conical tubercles very granulose; the surrounding region more sparsely and finely granulose; the distal margin of the telson and uropoda are denticulated by coarse granulations. Numerous fine setae are present on the dorsal surface of the carapace, these are interspersed among the granules and appear to be more abundant on the posterior margins of the telson and uropoda

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NOTES ON THE GILL-FINNED GOBY*

Bathygobius soporator (Cuvier and Valenciennes)

With an Explanation of the Specialized Pectoral Fin.

WILLIAM BEEBE, SC.D.

OUTLINE

INTRODUCTION: For a space of six weeks from July to August, 1930, my deep-sea trawling engine was out of commission and my bathypelagic work temporarily at a standstill. The fish nearest at hand was *Bathygobius soporator* which was to be found in every tide-pool on the shores of Nonsuch.

I collected a few, and studied them both in aquaria and in their own haunts. The following notes sum up my observations on this most interesting fish.

NAME AND HISTORY: In 1837 Cuvier and Valenciennes gave the name *Gobius soporator* to a fish which M. Achard had brought from the island of Martinique in the West Indies. Forty-one years later Bleeker considered that this species was worthy of separate generic distinction and called it *Bathygobius.* A less appropriate title could hardly be imagined for this inhabitant of tide-pools and other shallow waters. The specific name is a Latinized translation of the term by which the native West Indians know this species.

*Contribution, New York Zoological Society Department of Tropical Research, No. 360.

In Bermuda, in common with several other related species, this goby is called, for no apparent reason, Molly Miller, Sheep's head Molly Miller and Black Joe. Elsewhere it is known as the Sleeper, Babosa, Amoreia, Mapo, Caiman, Oopu, Too-goo, Silk-finned Goby, etc.

FIELD CHARACTERS: This is a medium-sized Goby, with united ventral fins free from the abdomen; head depressed, body compressed posteriorly; *pectoral fins with upper rays free and filamentous.*

GENERAL RANGE: Reported to be cosmopolitan in the tropics, but intensive study will probably show considerable geographical speciation. In the western Atlantic it has been recorded from Bermuda, Charleston, Florida to Colon and the West Indies, south to Bahia and Rio Janeiro.

OCCURRENCE IN BERMUDA: This is the commonest goby in the infrequent tide-pools, found sometimes on sand but generally on rocks. At low tide on August 20, 1930, a census of all tide-pools on the shores of Nonsuch showed one hundred and twenty-six fish; probably well below the actual number. In an isolated tide-pool on Cock Rock on August 24, there were twelve of these gobies, four of them over three inches in length. In shallow water observing from the diving helmet, I have seen this species as deep as two fathoms on sand.

SOCIABILITY: There is no schooling or concentrating of these fish other than the normal association which of necessity results from such a localized habitat. From three to seven fish are usually found in a tide-pool of good size, seldom more than one large one. Several times (six to be exact) I have changed marked individuals from one tide-pool to another, many yards away, and five out of the six times the transferred fish were found next day in their original pools. So there is apparently a definite habitat selection and a decided preference for a certain chosen spot. When crowded in an aquarium they will nip one another's tails, but I have never seen any evidence of serious attack in undisturbed individuals.

VIABILITY: The viability of these gobies is remarkable, although only what might be expected from their habitat in life. A newly caught goby 43 mm. in standard length displaced 2 cc. of water. It was placed in a glass dish holding 50 cc. of salt water with a surface exposure of 60 by 90 mm., where it lived in apparently normal strength and activity for six full days. It then collapsed and could scarcely move or turn over. So

I removed it and found that the water had evaporated to 21 cc. At first the water barely covered the fish, while on the last day or two most of its back was out of water. The fish revived in a few minutes in a large aquarium.

Fresh water seems to make no difference to this fish. After three days in fresh water with only slight aeration, individuals of this species showed no symptoms of discomfort. The rate of breathing was quite normal.

One of my gobies recovered full health after three hours of accidental drying on the dust of a cement floor, and after its eyes, gills and skin were thoroughly dry and coated with all manner of débris.

GENERAL FORM: The first glance shows that this goby is not built for continued speed or sustained activity of any kind. It has relinquished its ancestral heritage of motion in three planes of space and has struck bottom and remained there, paying the penalty of an unlovely rebalancing of its whole being and the resulting heaviness of general structure and form which characterizes terrestrial creatures as compared with those which inhabit the water and the air.

The general lateral outline of the body is as nearly an elongated rectangle as a fish can show. Anteriorly the body appears heavy and robust. The back slopes very slightly downward to the tail and the ventral profile is almost flat, a very evident adaptation for resting on the bottom. The head is rounded, the snout short and curved, merging halfway into the thick flat lips. The general lateral appearance is of a clumsy, awkward, inept species of fish.

The top view shows more shapeliness, the anterior half still thick and heavy, but the posterior tapering rapidly. The two views taken together reveal a vivid relation to the dominant activities in a two-plane life. There is little provision for up and down movements, but abundant adaptation in the narrow, laterally pliable peduncle, for quick left or right, forward or back twists, turns or darts.

From the top, the resemblance of the head to that of a frog is striking; the broad rounded mouth, the bulging eyes and the turgid jowls. The greatly swollen character of the opercles appears to be due to two dominant causes, first the necessity of lateral, not ventral movements in respiration, and the second, the need for an unusually strong, hence thick, operative musculature. These fish, in having to contend

with the smashing power of the waves and the tremendous pull and push of surging waters, could not avoid damage to any external delicate organs. The mouth is hence protected by great fleshy, yet deeply socketed lips. The eternal hydraulic pump which means life itself, avoids injury from the risks which stress of external force induces, by an over development of opercular muscles.

SIZE AND WEIGHT: Six inches is the maximum length of this species, and half that extent is a much more common size of adult individuals.

31 mm. (33 per cent)	.....	.8 grams (6 per cent)
51 mm. (55 per cent)	.....	2.5 grams (18 per cent)
79 mm. (85 per cent)	.....	8. grams (60 per cent)
93 mm. (100 per cent)	.....	13.5 grams (100 per cent)

The above table shows the relative percentages of length and weight.

SCALATION: In a goby of 21 mm. standard length the entire body is covered with scales except the head, the nape back to near the first dorsal, and the area around and behind the ventrals as far back as the anus. The scales bordering the clear nuchal area and between the pectorals and ventrals are very small, but normal in structure and in their moderately deciduous character. These soon give place to scales of average size. From the vertical of the first dorsal the scales increase in size steadily toward the tail, the largest being on the sides of the caudal peduncle.

In the 21 mm. specimen there are fourteen rows at the vertical of the first dorsal, and six rows at the tail. On one side of the fish I count 665 scales. Doubling this and including seventeen median ones, we have a total of 1347 scales on the entire fish. Their arrangement in longitudinal rows is as follows:

1st row, nape to 1st D—24.
2nd row, nape, nearly to end of 1st D—30.
3rd row, nape, to end of 1st D—44.
4th row, nape to caudal—43.
Remainder of nape scales—23.
5th row, end of nape to end of 2nd D—30.
6th row, end of nape almost to caudal—36.
7th row, top of P to C—36.
8th row, midline, P to C—35.

Fig. 12. Typical scales of *Bathygobius soporator*. A—Midline scale of a 31 mm. fish; B—Midline scale of a 72 mm. fish

9th row, P to C—38.
10th row, P almost to C—33.
11th row, P to caudal peduncle—55.
12th row, P to C—27.
Ventral area of small scales—180.
13th row, end of small scales to posterior end of V—17.
14th row, end of small scales to anterior end of V—12.
D line on caudal peduncle—7.
V line on caudal peduncle—10.

The scales are strongly ctenoid, probably a valuable asset in aiding the fish to retain its hold and resist the stress of breaking waves. They are remarkably uniform and vary chiefly in relative size and slightly in shape.

For illustration I have chosen a scale from two individuals, taken in each case from the 8th or mid-line row, the seventh scale from the caudal end. A is from a fish of 31 mm. standard length, B from one 72 mm. long.

	Standard Length	Scale Length	Scale Width	Length Ctenoid Spines
Specimen A..........	31 mm.	1.4 mm.	1.2 mm.	41 mm.
Specimen B..........	72 mm.	3.0 mm.	2.9 mm.	22 mm.

Specimen A: The exposed or posterior edge of the scale slopes backward 35° evenly above and below from an obtuse central angle. Along this side are 40 slender sharp teeth, with stout bases, pointing at right angles to their individual bases. An inferior tissue of skin reaches to their tips. The hidden or anterior edge of the scale has the same angles as the posterior edge but the center has a slight notch. The dorsal and ventral contour between the slopes of the other edges are

horizontal. From the anterior edge to half-way along the dorsal and ventral planes there extend twenty-three radii, horizontal centrally, but becoming slightly oblique above and below. These reach about three-fifths over the entire scale, giving place to an area of broken lines and irregular markings. Between each of the transverse lines are stout, fine, concave circuli, none of these quite reaching the radii themselves. On mid-scale there are about thirty of these before they dissolve into irregular hieroglyphics. Beyond the last dorsal and ventral transverse markings, the short circuli become lengthened into about ten lines which parallel the outer border of the scale.

Specimen B: The scale is much more rounded posteriorly, but with the flat dorsal and ventral contour and the anterior angles and notch as in Specimen A. The spines have increased to 74, and are longer and more slender. The increase has been by the intercalation of small spines between the larger ones, which seem to have no definite basal attachment. The larger teeth, whose bases connect with one another, represent the original ones, as they are forty-four in number.

The radii have increased to thirty-six, but nine of these are imperfect, absent at one or the other end. The circuli have remained as fine as before, but about doubled in number. The transparent skin on the entire exposed portion, about one-half of the whole scale, is sparsely covered with fine black chromatophores.

In the nuchal mid-line scales, lying just before the 1st D, the posterior line of spines is altogether lacking, the entire scale being occupied by about twenty radii and the intervening circuli.

On the side of the fish close behind the pectoral, the scales are much reduced in size, and the teeth are cut down to 21, a small number but all of full size and normal structure.

PIGMENTATION: The basis of the pigmentation in this goby is quite simple. A low power lens shows the transparent dermis of the living fish covered more or less solidly with a multitude of small, greyish-white chromatophores, circular, with fairly regular circumference. In the center of each is a small black dot—round and dense. The darkening of the light ground color is caused by the dendritic enlargement of this central black chromatophore. On many parts of the body the heart of the black spot is intense blue, and this is strong enough to show up brightly in certain liveries. When orange appears it is in the form

of very small round spots in the white border. If the black remains contracted and the orange chromatophores expand, the general effect is of a solid orange or golden area. In one dark phase the dominant color is green and this appears to result from a juxtaposition of the blue and the golden. After death the separate character of the large white areas is lost.

Usually, when the dark cells expand, they become dendritic, but on the cheeks they may enlarge into curious square or pentagonal outlines and remain firm all along the contours.

COLOR: Few fish show such radical color changes as the gobies and I believe it would be possible to make half a hundred slightly different paintings of a single individual. But there is an average mean—a usual livery which may be used as the basis of description. It is difficult of exact description, for the instant one of these gobies is caught or killed the entire pattern and visible pigmentation changes. The only safe way is to attract all the gobies of pool after pool with a bait of crushed chitons and then with a short focus glass to watch and record and compare every detail of the coloration.

In Bermuda specimens there are four well marked extremes of pattern and color, and these may be described and defined as follows:

Color phase A—Normal—Black and White.

Color phase B—Fear—Blue-Spotted, Dark Green.

Color phase C—Nocturnal—Banded.

Color phase D—Sand—White.

Color phase A, Normal: I call this the normal phase because it is the usual livery of the undisturbed gobies in the rocky tide-pools (not on the sand). In an aquarium, after a day or two, when they have become used to the new conditions they return to at least an approximation of this coloring.

In this phase there are about ten narrow lines of white, and ten of dusky gold extending down the whole body. The white is rather less connected but to the unaided eye, dominates the gold. This is because the gold is oxydized with very dilute, dendritic, brown chromatophores, which deaden the yellow and make it appear dark. The purity and sheen of the white produces a curious appearance of a series of ribs in high relief.

On this lateral background are three linear series of large dark

blotches, cut into more or less oval shapes by the white longitudinal lines. These gross markings extend from the back two-thirds down the sides, and on the peduncle become reduced to five or six round, dusky spots.

This pattern and coloring are all derived from the dermis. Aside from a few, small, scattered black dots, the scales are colorless. When a patch of these is removed the important chromatophores appear. The golden are interspersed with brown ones, the white are strengthened by a substratum of solid silver.

On the opercles the dark chromatophores are dominant, forming a solid background for numerous, small, round, white spots. There are three, large but indistinct dark blotches on the preopercle, and in some cases an irregular, dark, pale-bordered band extends from the eye to the upper limb of the pectoral.

The fins all show more or less distinct, but broken, bands of black and white, the anterior spine of the first and second dorsal being always sharply marked. Dark blotches may come and go on the lower cheeks and on the pectoral bases.

Color phase B—Fear: This is essentially a dark green pattern, and is assumed at moments of extreme fear. A goby usually changes very suddenly into this when dipped up roughly from its pool, or, when cornered, it attempts to leap from one pool to another. On making its escape after being thoroughly alarmed, the fish invariably seeks concealment in a crevice, a dark hollow, or among and in dark green seaweed. Hence this sudden shift of color is explicable by the speed and character of the change in environmental background. The shift is almost instantaneous, but the reverse is very gradual, probably from the slow dying down of the more violent emotion than from any physiological cause.

The general color of the head, body and fins is dark green, the head decidedly darker, while both dorsal fins show a wide margin of yellow. Over the head and body there appears an abundant scattering of small blue dots.

Color phase C—Nocturnal: The most common pattern and color assumed at night is a banded one wholly unlike any other extreme phase, although often shown in transitory light tints. It is frequently assumed when oxygen is lacking and the fish is feeling the need of fresh water. Looked at from above, the nape and snout are black, the rest of the head back to the first dorsal seal brown; then another black band and a brown

Fig 11 Color phases of *Bathygobius soporator* A—Normal, B—Fear, C—Nocturnal, D—Sand, E—Front view of goby supported by the vacuum formed by the ventral fins From a painting by Else Bostelmann

band of equal width, followed by a narrow black, a white, and a brown band on the peduncle. The two broad black bands are bordered with a wide margin of white.

Color phase D—Sand: When on hot, sunlit sand, the gobies change again, this time bleaching out almost every dark marking, except very faint ones on the fins. When completely sand adapted the fish are absolutely invisible, their sessile position avoiding shadows, and their color exactly that of the grains of sand.

FINS: This fish, like most gobies is generously provided with fins, the eight separate structures being supported by one hundred and ten spines and rays. Unusual specialization is evident only in the four paired fins, the upper rays of the pectorals being free, delicate and soft, and the ventrals being joined together in a vacuum-making cup—typical of many species of the family.

Elsewhere this goby seems to show considerable variation in fin rays, but in sixteen Bermuda individuals measuring from 20 to 70 mm. in length, there is only a single instance of variation. This is in a fish 55 mm. long, in which there is an additional superior caudal spine, making eight. The corresponding ventral element is represented only by a merest dot of bone.

The very consistent fin count in Bermuda specimens is as follows:

Dorsal VI—I, 10
Anal I, 9
Caudal VII—17—VII
Pectoral 20
Ventral I, 5

RESPIRATION: When the goby is resting quietly and breathing normally, the respirations number about two every second. The movement brings into play all the bones of the mouth, jaws and throat. The mouth never closes, in fact its entire movement is very slight, much less than that in the average fish. The mouth opens, draws in water, then partly closes and the internal, labial, membrane veils close together while the opercles at the rear spread out laterally and draw the water back simultaneously with the closing down of the pliant branchiostegals over the skin back of the pectorals; the movements follow one another rapidly and smoothly.

Ordinarily this is the only respiratory movement, but when the

oxygen content gets low, in an aquarium or in an isolated, high-set, super-heated tide-pool, then the second line of breathing comes into play —the upper fourth of the pectorals, bearing the long, webless, soft rays and raylets, begins to wave back and forth. They move synchronously and are timed exactly to take advantage of the stream of water coming from the gill-openings. As the branchiostegals close down, ejecting the last mouthful of water, the pectoral gills move forward. When this process is in full swing the pectoral fins as a whole are raised and spread out laterally, but only the upper part—no more than a fourth of the entire fin, is in motion. I have seen it in play when the pectoral fins had to keep firm grip on a rock, and under such conditions the mobility of muscular movement and the sharp distinction between the actively waving part and the immobile lower section was very sharp and striking. The number of the free rays varies, but there may be as many as fourteen undivided secondary branches. Curiously enough these rays are less sensitive to touch than are the other, less specialized rays. Neither from direct observation in life, nor in microscopic observation do I find any confirmation of the tactile function which has been suggested by some authors—". . . les rayons supérieurs devenus crinoïdes servent d'organes du tact."

The gill-openings are admirably adapted for functioning in a tide-pool. Their complete opening is about the width of the muscular base of the pectoral and these apertures are placed close to that fin. As these fins are wholly lateral, it follows that the fish can flatten its head and thoracic region on the bottom of the pool without interfering with the full respiratory action.

Instead of simple tips to the rays of the remaining fins, we find that there are a multitude. To take the first coarse divisions, we find that a total of 89 fin rays shows a division into 456 tips. Individual fins are as follows:

Pectoral: 21 rays and 92 tips.
Ventral: 5 rays and 43 tips.
Second dorsal: 9½ rays and 41 tips.
Anal: 9½ rays and 54 tips.
Caudal: 17 rays and 91 tips.

Each of these tips has in turn a more minute subdivision into 4 to 8, and taking 6 as a fair average, we have 2736 distal, fingerlike, fleshy,

highly vascular projections, which apparently can function, when waved through the water, as a third respiratory reserve.

Thus the tips of all the rays of all the fins (except the first spiny dorsal) are branched and take up no bone stain. The significance of this was not apparent until I watched a goby for a long time in a small plate-glass box. Some time after he had begun to feel discomfort, when the pectoral gill-rays were working rapidly, I saw him begin to wave all the fins of the body—second-dorsal, anal, caudal, and even the ventrals swaying back and forth. The whole body waved sideways through a small arc. Only the first spiny dorsal was flattened and invisible. All the others were raised or expanded to their full limit. There seemed no doubt that the goby was helping out his over-worked gills with the sensitive tips of all the fins. When suspicious of my close approach the movement of the body ceased first, and later when much worried, he stopped the vibrating of the pectoral rays. Just before the fish turned rapidly to escape, the gill movement itself ceased.

The value of these auxiliary breathing organs in enabling the fish to endure temporary imprisoning in an unoxygenated pool is beyond estimate. It would make all the difference in a question of existence or nonexistence in many places, and the fish probably owes its great abundance and wide distribution to this ability, affording such a great advantage over related forms which must depend solely upon the usual respiratory apparatus.

Membranous Labyrinth and Otoliths: The two membranous labyrinths of *Bathygobius soporator* are similar in general construction to those of other teleostean fishes, consisting of sacculus, utriculus, and semicircular canals, but in a few respects are highly specialized. They, together with the contained otoliths, are well developed, but the cranial cavity, in fact, the whole skull, is relatively shallow. Therefore, they must in some way be compressed vertically to fit in the small available space. This has been accomplished by an actual folding over of the entire organ, in much the same way that a sheet of writing paper is folded to fit its envelope.

The utriculus, instead of being dorsal to the sacculus, which is the normal position, is ventral to it, and is connected with it by a membranous canal. The semicircular canals issue from the utriculus and execute their arcs close to and about the sacculus, not in the cartilage and bone

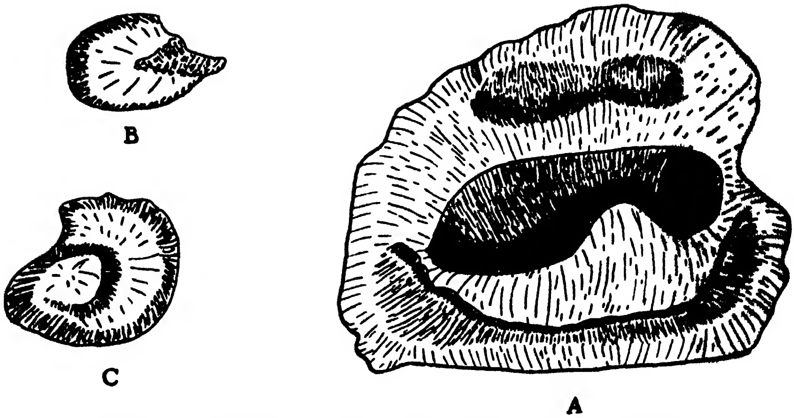

Fig. 13. Otoliths of *Bathygobius soporator*. A—Sagitta. B—Asteriscus; C—Lapillus.

above it. The horizontal semicircular canal completely encircles the sacculus and sagitta.

The two sacculi and their otoliths, the sagittae and asterisci, are contained in cup-like depressions, called the *saccular cavities*, which occupy the sides of the cranial cavity posteriorly, reaching quite from top to bottom. They slant backward, inward, and downward, following the inward obliquity of the cranial cavity.

There are three otoliths contained in each membranous labyrinth: a sagitta, an asteriscus, and a lapillus. The sagitta, which is by far the largest and best developed of the three, has its inner side slightly convex and its outer side correspondingly concave. It rests upright, or perhaps with a slight outward slant in the sacculus, its outline anteriorly fitting closely the oval contour of the saccular cavity.

The asteriscus, the smallest of the three otoliths, is contained in a blind pouch—the cochlea—extending posteriorly from the sacculus. It is oval in shape and is characterized by a definite anterior rostrum and a sulcus. This is remarkable, because in most teleosts the asteriscus is rather characterless.

The lapillus is about one-third again as large as the asteriscus and is round and thick in general contour. It is situated in the utriculus and is therefore ventral to and slightly inside of the sagitta.

The dissection and drawings of the otoliths of this fish were made by Mr. Patten Jackson. The painting of the color phases is the work of Else Bostelmann.

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STIMULATION BY ADRENALIN OF THE LUMINESCENCE OF DEEP-SEA FISH*

BY E. NEWTON HARVEY
Princeton University

Collecting deep sea animals in good living condition is very difficult. Whether affected by change in pressure, or temperature, or asphyxiation in the bottles at the end of the nets, it is unfortunately true that most deep sea forms come up quite dead and motionless. Occasionally they are living.

Through the great kindness of Dr. William Beebe, Director of the Bermuda Oceanographic Expedition of the New York Zoological Society, I have recently had an opportunity of studying the luminescence of a large deep sea fish, *Echiostoma ctenobarba*, two specimens of which, about one foot long, were brought into the laboratory in iced sea water in the living condition. They were caught at eight hundred fathoms.

In *Echiostoma* there is a prominent cheek organ and two rows of large photophores along the ventral and lateral walls besides numerous minute photophores scattered over practically the whole body including the dorsal surface. The cheek organ is partially pink in life and was observed to flash with a decidedly bluish luminescence when the fish was handled, especially when lifted out of the sea water. No other luminescence of any kind could be noted, however, despite the fact that the fish was squeezed and twisted to stimulate it strongly. A hypodermic needle was then inserted but no luminescence additional to that of the cheek organ appeared. However, when a little adrenalin (1 :1000 in physiological salt) was injected with the hypodermic into the side about one-third toward the tail end, there immediately appeared a yellowish luminescence of photophores locally, near the point of injection and soon practically all of the photophores of the fish were luminescing with a yellowish moderately intense continuous glow. This lasted a few minutes and then went out and could not be excited again by rubbing or handling but appeared as before on a second, third and fourth injection of adrenalin. The last injection was of ten minims and excited all or-

*Contribution, New York Zoological Society Department of Tropical Research, No. 361.

gans and also the pectoral and ventral fins. There is no doubt of the luminescence of these fins despite the fact that they do not possess any marked organs. No luminescence was observed in the tail, anal fins, long pectoral rays, or barbel on lower jaw. The cheek organ flashed at intervals after adrenalin injection but did not change in rhythm or in any noticeable way. The flashing of this organ is not due to unscreening of a continuously luminous surface. The light appears and disappears on the organ itself and for this reason we may presume that *Echiostoma* is self luminous and does not harbor luminous bacteria as is the case in the Dutch East Indian fish, *Photoblepharon* and *Anomalops,* which also possess cheek organs.[1]

There is no doubt of the stimulating action of adrenalin on these photophores. The observations add a second example of luminous fishes known to be excited to luminescence by adrenalin. The first was the California toad-fish, *Porichthys,* described by Greene and Greene.[2] It is a surface form, difficult to stimulate in other ways but which gives a brilliant long lasting glow of its eight hundred odd photophores after injection of adrenalin. The fire-fly also glows continuously and brightly after adrenalin injection.[3]

As the photophores of *Porichthys* receive a very sparse nerve supply, Greene believes that adrenalin acts directly on the photogenic cells. I can state, however, that it does not cause luminescence of the worm, *Chaetopterus,* or of hydroids. In the fire-fly there is considerable evidence of a nerve-muscle mechanism controlling the flash.[4] Studies of the photophore nerve supply of deep sea fish would be very valuable and are much needed.

It should be mentioned that adrenalin is not a stimulant for light production after a fish has been dead some time. Other dead deep sea fish, and even a feebly moving *Linophryne arborifera* could not be made to light by injecting adrenalin. For the physiologist, the great problem is to get the material in good living condition. It is my belief that increased temperature is the chief lethal factor. When we remember that temperatures a mile deep are four to five degrees Centigrade while the

[1] *Harvey, E. N.* The Production of Light by the Fishes. Photoblepharon and Anomalops. Pub. No. 312 Carnegie Institution Washington, p. 43, 1922. Natural History *25*, 353, 1925.

[2] *Greene, C. W.* and *Greene, H. H.* Phosphorescence of Porichthys notatus, the California Singing Fish. Amer. Jour. Physiol., *70*, 500, 1924.

[3] *Creighton, W. S.* The Effect of Adrenalin on the Luminescence of Fire-flies. Science, *63*, 600, 1926.

[4] *Dahlgren, U.* The Production of Light by Animals. Jour. Franklin Inst. March and May, 1917.

surface water is twenty-five degrees Centigrade, and also that it takes over an hour to haul in the nets, we realize the unfavorable conditions to which these deep sea forms are subject. Perhaps we are lucky to observe luminescence under any circumstances.

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CHEMICAL ASPECTS OF THE LUMINESCENCE OF DEEP-SEA SHRIMP*

By E. Newton Harvey
Princeton University

It is convenient to group all luminous organisms into two great classes, those which produce a steady continuous light quite independent of stimulation, the luminous bacteria and the fungi, and those whose luminescence appears only on agitation or stimulation of some kind, including all the others. These may again be divided into forms whose light is intracellular like *Noctiluca* and the fire-fly, and those with extracellular luminescence, forms which secrete a luminous slime or which throw a fluid from glands into the sea water in which they live. Many medusae and the ostracod crustacean, *Cypridina,* belong in the latter group.

Such forms often store up a very large amount of luminous material which they pour out, surrounding themselves with a barrage of fire behind which we may suppose they make their escape from the jaws of some predacious enemy. The most notable and spectacular animal of this class is a small squid, *Heteroteuthis dispar,* found in the Mediterranean and especially at Messina, where I have had the opportunity of studying them. Most of the ink sac has become transformed into a luminous gland. When disturbed, the glowing secretion is shot out thru the siphon as a cloud of luminescence that surrounds the animal. Attacking fish would be subjected to a veritable bombardment of liquid fire quite as startling if not as dangerous as any developed during the war. It is almost paradoxical to find an organ developed for producing the very blackest material, suddenly transformed into one manufacturing not only a clear fluid but a fluid actually shining with its own light.

Such a mechanism of defence must be quite effective, for several other creatures have appropriated the idea. One of these is the deep sea shrimp or prawn, *Systellaspis.* Such forms were first described by Alcock[1] and observed by Beebe[2] during the "Arcturus Ad-

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*Contribution, New York Zoological Society Department of Tropical Research, No. 362.
[1]*Alcock, A.* A Naturalist in Indian Seas, p. 134 1902.
[2]*Beebe, W.* The Arcturus Adventure 1927.

venture". Through the kindness of Dr. Beebe, I have recently had an opportunity of making some observations on the chemistry of luminescence in these forms, which have been obtained quite regularly in the tow nets from 600-800 fathoms, about 10 miles south of Nonesuch Island, Bermuda. The shrimp is about 1½ in. long, bright red in color, with a well spiked rostrum, very long antennae and a row of black dots along the sides. These dots are luminous organs although I have never seen light coming from them.

When brought to the surface and placed in iced sea water, since they come from depths where the temperature is about 5 C., they live for several hours, and with well dark adapted eyes one can see that this sea water is aglow with their luminescent secretion, the light lasting for some time. Touch the shrimp with a rod and immediately a cloud of bluish luminescent secretion is shot out from glands near the mouth, and is carried by convection currents thru the sea water.[3]

The luminescence of all organisms is the result of a slow burning or oxidation of a definite compound luciferin, in the presence of an enzyme luciferase. This was first proven to be the case by Dubois in 1886 in the large West Indian elaterid beetle, *Pyrophorus,* later in the mollusc, *Phelus dactylus,* and since then I have found these bodies in lampyrid fireflies, the ostracod crustacean, *Cypridina,* the worm, *Odontosyllis,* and Hickling has described them in the fish, *Malacocephalus laevis.*[4] Curiously enough it is not possible to demonstrate luciferin and luciferase in many of the 40 odd orders of animals containing luminous forms. As the opportunity has appeared I have been studying this point over a period of fifteen years, and table 1 shows the organisms tested and the group to which they belong.[5] Of special interest is the question as to whether the luciferin of one species will react with the luciferase of another. It is not possible to obtain simultaneously all the luminous animals that one would like to test but the ostracod, *Cypridina*, can be dried and its power of luminescence retained indefinitely (at least over a period of 12 years). light appearing whenever the dried animals are moistened. Table 1 shows also how other organisms react with *Cypridina* luciferin and luciferase.

[3]For histology of the organs see Dahlgren, U. The Production of Light by Animals. Journ. Franklin Inst. June 1917.

[4]For Chemistry of luminescence see Harvey, E. N., The Nature of Animal Light 1920; Recent Advances in Bioluminescence. Physiological Reviews 4, 639, 1924. Bioluminescence. Bull. Nat. Research Council. No. 59, p50, 1927.

[5]*Harvey, E. N.* Additional Data on the Specificity of Luciferin and Luciferase, together with a general survey of this reaction. Am. J. Physiol. *77,* 548, 1926.

The preparation of luciferase and luciferin solutions is very simple. The former is obtained by merely making a cold water extract of the luminous organ, when both luciferin and luciferase dissolve and the luciferin oxidized with luminescence in a short time, leaving the luciferase (an enzyme) behind. Like all enzymes, luciferase is destroyed on boiling, whereas luciferin is not. Consequently luciferin is prepared by making a hot water extract of the luminous organ and cooling. This luciferin solution is quite dark but when mixed with luciferase, also dark, will again produce light.

It was found that *Systellaspis* luciferin mixed with *Systellaspis* luciferase would give a good luminescence, whereas *Systellaspis* luciferin mixed with *Cypridina* luciferase produced no light, nor would *Systellaspis* luciferase give light with *Cypridina* luciferin. This is quite in line with all the previous evidence I have been collecting[5], namely, that the luciferin-luciferase reaction is specific, that luciferin will not react with luciferase of other species belonging to a different group. However, the case of *Systellaspis* is of especial interest, sinse its luminescence is bluish and looks exactly like that of *Cypridina*, and the two forms are Crustacea, fairly closely related. It is the first time I have had the opportunity of testing two orders within the same class.

Only if luminous animals are very closely related, will the luciferin of one species react with the luciferase of another, as two genera of fire-flies or two genera of ostracods. In this case an interesting experiment can be carried out where the luminescence of the two species differs in color, as in fire-flies of the genera *Photinus* (reddish luminescence) and *Photuris* (yellowish luminescence). Intermixing luciferin and luciferase of these genera shows that the color of the resulting luminescence is not intermediate but is that of the fire-fly supplying the *luciferase*. This must mean that luciferase is the source of the light. From this and other evidence I have come to the conclusion that the energy for luminescence comes from the oxidation of luciferin.[4] The luciferase plays two roles:—(1) that of an enzyme, accelerating the oxidation of luciferin. (2) to supply molecules which can easily pick up the energy set free in oxidation. Such molecules the chemist call "excited molecules" and their excess energy can be liberated as radiation which we see as the luminescence of the animal. The color (wave-length) of the radiation will depend on the specific chemical configuration of the luciferase mole-

cules, which differ in different species and is so different in different groups that excitation cannot occur at all.

Thus, *Systellaspis* has supplied a very necessary link in our chain of evidence concerning the luciferin-luciferase reaction and I express my sincere thanks to Dr. Beebe, Director of the Bermuda Oceanographic Expedition of the New York Zoological Society for making it possible to obtain these unusual forms.

TABLE I

Group	*Species*	*Place*	*Luciferin-Luciferase reaction*	*Reaction with Cypridina luciferin and luciferase*	*Reported by*
BACTERIA	*Bacillus fisheri*	Princeton	—	—	Harvey
	Photobacterium phosphorescens	Woods Hole	—	—	Harvey
	Photobacterium javanese	Java	+	not tried	Gerretsen
FUNGI	*Panus stipticus*	Woods Hole	—	—	Harvey
SPONGES	*Grantia*	Friday Harbor	—'	not tried	Harvey
RADIOLARIA	*Collozoum inerme*	Naples	—	—	Harvey
	Thalassicola nucleata	Naples	—	—	Harvey
CYSTOFLAGELLATES	*Noctiluca miliaris*	Japan	—	—	Harvey
MEDUSAE	*Aequorea forskala*	Friday Harbor	—	—	Harvey
	Mitrocoma cellularia	Friday Harbor	—	—	Harvey
	Pelagia noctiluca	Naples	—	—	Harvey
PENNATULIDS	*Pennatula phosphorea*	Naples	—	—	Harvey
	Cavernularia haberi	Japan	—	—'	Harvey
	Ptylosarcus sp. ?	Friday Harbor	—	—	Harvey
CTENOPHORES	*Bolina sp. ?*	Friday Harbor	—	—	Harvey
	Mnemiopsis Leidyi	Woods Hole	—	—	Harvey
	Beroe ovata	Naples	—	—	Harvey
	Eucharis multicornis	Naples	—	—	Harvey
OPHIURIANS	*Amphiura squamata*	Naples	—	—	Harvey
ANNELIDS	*Odontosyllis phosphorea*	Bermuda	+	—	Harvey
	Tomopteris helgolandica	Plymouth	—	—	Harvey
	Polycirrus caliendrium	Plymouth	—	—	Harvey
	Chaetopterus variopedatus	Woods Hole	—	—	Harvey
	Harmithoe imbricata	St. Andrews, N.B.	—'	—	Harvey
	Acholoe astericola	Naples	—	—	Harvey
	Misroscolex phosphorea	Naples	—	—	Harvey
OSTRACODS	*Cypridina hilgendorfii*	Japan	+		Harvey Kanda
	Pyrocypris sp. ?	Java	+	+	Harvey
	Cypripina sp. ?	Jamaica, B. W. I.	+	+	Harvey
COPEPODS	*Metridium sp. ?*	Naples	—	—	Harvey
SCHIZOPODS	*Meganyctiphanes norvegica*	St. Andrews, N B.	—	—	Harvey
DECAPODS	*Acanthephyra sp. ?*	Bermuda	+	—	Harvey
MYRIAPODS	*Geophilus sp. ?*	Java	—*	not tried	Harvey
INSECTS	*Pyrophorus noctiluca*	Cuba	+	not tried	Dubois Harvey
	Luciola viticollis	Japan	+	—	Harvey
	Photinus pyralis	Princeton	+	not tried	Harvey
	Photuris pennsylvanica	Princeton	+	not tried	Harvey
LAMELLIBRANCHS	*Pholas dactylus*	Mediterranean & Plymouth	+	—	Dubois Harvey
CEPHALOPODS	*Watasenia scintillans*	Japan	—	not tried	Harvey
	Heteroteuthis dispar	Messina	—'	—	Harvey
ASCIDIANS	*Pyrosoma sp. ?*	Monaco	—	—	Harvey
BALANOGLOSSIDS	*Ptychodera sp. ?*	Bermuda	—	—	Harvey
	Balanoglossus minutus	Naples	—	—	Harvey
FISH	*Photoblepharon palpebratus***	Banda Island	—	—	Harvey
	*Anomalops katoptron***	Banda Island	—	—	Harvey
	*Monacentris japonica***	Japan	—	not tried	Harvey
	Malacocephalus laevis	England	+	not tried	Hickling

*Dilute solutions.

**Contain luminous bacteria.

NEW TEREBELLID ANNELIDS

THELEPUS HAITIENSIS and TEREBELLA HIATA*

Two New Species From Haiti.

By A. L. Treadwell,
Vassar College.

(Fig. 14)

Through the courtesy of Director Beebe the polychaetous annelids collected on the 1927 expedition of the New York Zoological Society to Haiti were submitted to me for examination. While most of the material was made up of old species, two are new, and their description follows.

Thelepus haitiensis, sp. nov.

Collected at Station 27418. The type is in the collections of the New York Zoological Society.

The type is 85 mm. long and contains about 80 somites but is incomplete posteriorly. The prostomial width is 2 mm. From the anterior end the body rapidly increases in width as far as the region of somite 15 Somites immediately behind this point are smaller than somite 15 and at somite 38 there is an abrupt narrowing, the diameter from here to the posterior end showing only a very slight decrease. The upper lip is rather heavy and smooth, having a recurved margin and longitudinal lines on its inner face. A transverse band forms the lower boundary of the mouth. Behind this is a broader band, its width equalling about one-half of its length, the ends curving so as to enclose and cover over the transverse band above mentioned. There is no trace of eye spots. The tentacles are of varying sizes, the largest relatively very heavy. All are grooved longitudinally.

There are three pairs of gills on somites 2, 3 and 4. Each gill arises as a transverse basal ridge whose free edge is prolonged into a large number of fine filaments smaller than any tentacles, and all having a peculiar translucent appearance. A space equal in width to about that of one quarter of the gill-base, separates the gill of one side from that of the

*Contribution, New York Zoological Society Department of Tropical Research, No. 363.

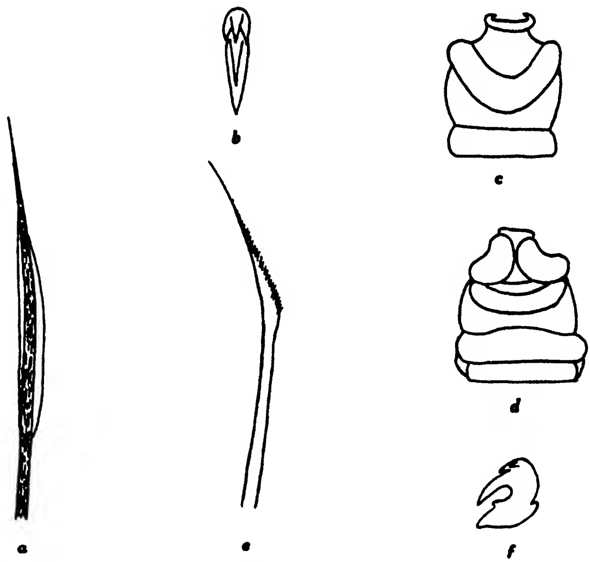

Fig. 14. A—Seta of *Thelepus haitiensis* x 250. B—Uncinus of *Thelepus haitiensis* x 250. C—Anterior end of *Terebella hiata*, dorsal view, x 10. D—Anterior end of *Terebella hiata*, ventral view, x 10. E—Seta of *Terebella hiata* x 250. F.—Uncinus of *Terebella hiata* x 250

other. In length and number of filaments the first gill is larger than the second and the second larger than the third. The ventral shields are most prominent anteriorly, less so toward the posterior end, the median furrow is distinct and each shield more or less wrinkled on its margins.

The first setae are on the third somite, while uncini begin on somite five. The setae are all slender, bilimbate (Fig. 14a), widen a little toward the end and terminate in a sharp point. The uncini are in a single row in each uncinigerous somite, (Fig. 14b). Each uncinus has a powerful hook, with two or three smaller hooks at the apex. Both setae and uncini extend to the posterior end of the body and are similar in character throughout.

TEREBELLA HIATA, sp. nov.

Collected at Station 27289. The type is in the collections of the New York Zoological Society.

The type is 80 mm. long with a prostomial width of 1½ mm. Body measurements in terebellids are deceptive because through mus-

cular contractions or through the action of preserving fluids the soft bodies of these annelids are usually distorted. In the type as it appears after preservation the width at the eighth somite is 4 mm. and this width is approximately maintained as far back as somite 22. Posterior to this point, the body narrows decidedly and the pygidium is not more than 0.25 mm. wide.

The tentacles are long and heavy and deeply grooved longitudinally. They arise from a broad basal plate which extends posteriorly over the first somite (Fig. 14c). Dorsally the upper lip seems rather thin, but ventrally it is thicker and bends around so that (Fig. 14d) it appears as a sausage-shaped lobe on either side of the mouth, the two lobes almost meeting in the mid-ventral line. The lower lip is small. There are no eye spots visible. The first somite is about as long as the two following somites taken together, later ones increase slightly in length but owing to obvious distortions no definite rule can be given as to these variations. There are 14 ventral shields, increasing in length but decreasing in width, from in front posteriorly.

There are three pairs of gills on somites 2, 5 and 8. The third pair are more than twice as long as the first, the second intermediate between these. Each gill arises by a stout basal stalk which divides in an irregularly dichotomous fashion to end in a dense tuft of short branches.

The simple setae begin on somite 4 and probably occur in all somites though I was unable to demonstrate them in the last 3 mm. of the body. They have stout shafts. The apical region is bent nearly at right angles, drawn out into a sharp point and toothed along the edge (Fig. 14e). The apex of this flattened portion is often curved into a different plane from that of the main part. The uncini are sometimes in one, sometimes in two, rows. Each (Fig. 14f) has a stout hook with a smaller apical one, and much smaller ones on either side of this. Only one of these is figured.

Zoologica, Vol. XII, No. 9

NEW SPECIES OF FISH FROM THE WEST INDIES[1]

BY WILLIAM BEEBE AND GLORIA HOLLISTER

Long-barbelled Flyingfish

CYPSELURUS ANTAREI SP. NOV.

(Fig. 15)

TYPE: *and only specimen, Antares Expedition Number 6. June 30, 1932. At 2 P. M. flew on board Yacht Antares, in 21° 50′ No. Lat. and 63° 32′ West Long., about two hundred miles north of Sombrero, B. W. I.*

MEASUREMENTS: Total length 85 mm.; Standard length 71 mm.; Depth 14 (5); Head 19 (3.7); Eye 6 (3); Snout 4 (4.7); Dorsal 13; Anal 9; Pectoral length 45 (1.5); Pelvic length 28 (2.5); Barbel length 73, reaching to end of body (lower jaw being 2 mm. in advance of upper).

COLOR: Steel blue above, light below, changing to silvery; vertical fins clear; pectorals pale at base, blackening toward tips; distal four-fifths of pelvics black.

BARBEL: The barbel of this fish is single, extremely soft and delicate, tapering very gradually from its base on the lower lip to the spider-web-like tip. It is attached around the entire curve of the mandible and is continued on each side into a rounded flap. The outer edges of the two flaps are joined by membrane to the outer sides of the barbel so that when it is extended to the full, backward, there is a very broad, rounded area of curved tissue (the hollow enclosing the lower jaw and chin), which rather abruptly flattens out into the wide, slightly curved ribbon of the barbel.

This is jet black, studded with minute blue dots, except down the center which is paler. Beneath, the central area widens rapidly until its fleshy white has replaced almost all the black pigment, but the black of the upper side holds strongly to the very tip.

[1] Contribution, New York Zoological Society, Department of Tropical Research, No. 410.

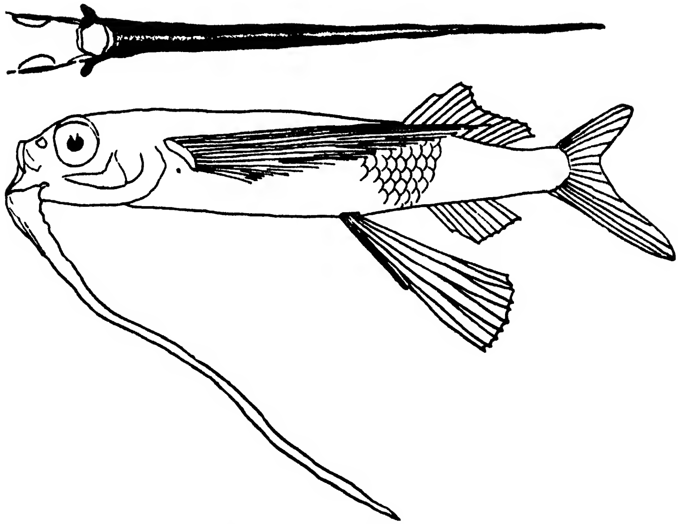

Fig. 15. Long-barbelled Flyingfish, *Cypselurus antarei* sp nov The upper figure represents the anterior side of the barbel.
Drawing by Helen Tee-Van

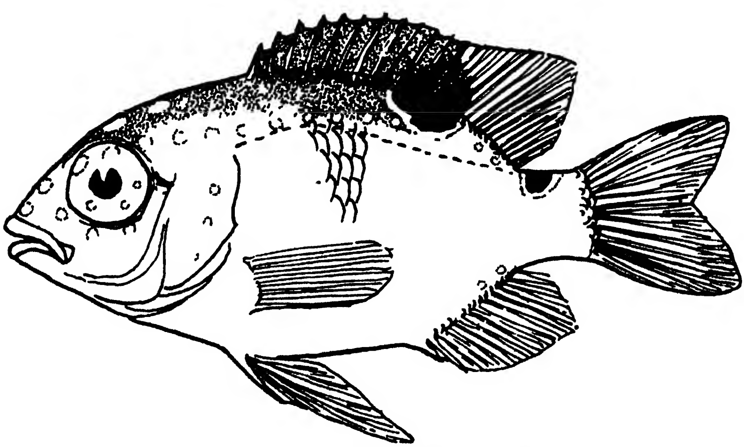

Fig. 16 Scarlet-backed Demoiselle, *Eupomacentrus rubridorsalis* sp nov
Drawing by Helen Tee-Van

Compared with Nichols and Breder's *Cypselurus monroei*, this fish is 3 instead of 2 inches long; the barbel is single, not double; tissue-like, not fleshy; flattened, not fluted; as long as the body, not half as long, and it arises from the lip, not the chin.

Scarlet-backed Demoiselle

A new and abundant species of this group

EUPOMACENTRUS RUBRIDORSALIS SP. NOV.

(Fig. 16)

DISCUSSION: On the twelfth of August, 1930, while swimming along the north-east shore of Nonsuch, Bermuda, and looking down through a water-glass, I saw a brightly colored Demoiselle quite new to me. The following day, in company with Hollister and Crouch I again found the fish, two of them this time, near the same place, about a coral boulder. I tried in vain to capture them on three successive days and after scrutinizing them carefully I finally exploded a dynamite cap near them, but could find no trace and never saw them again. I dictated the details of pattern and coloration for a colored plate and forgot about them.

In July 1932, on the Antares in the West Indies, Hollister and I found this species to be very common in certain of the islands, and have named and described it as follows:

EUPOMACENTRUS RUBRIDORSALIS, sp. nov.

TYPE: *Antares Number 97; Fifteenth Expedition of the Department of Tropical Research of the New York Zoological Society; July 9th, 1932. Taken near shore in Chatham Bay, Union Island, Grenadines, B. W. I. Standard length 15.5 mm. A second specimen, Antares Number 145, was taken July 18th, 1932, in a tidepool in Deep Bay, Antigua. In length, measurements, pattern and coloration the two are identical.*

FIELD CHARACTERS: A typical Demoiselle in shape and habits; dark blue in general, with top of head, upper sides and spinous dorsal fin scarlet; two ocelli, black with turquoise border, one between

spinous and soft dorsal, and the other on upper aspect of caudal peduncle.

MEASUREMENTS AND COUNTS: Total length 17.8 mm.; Standard length 15.5 mm.; Depth 7.5 (2); Head 6 (2.58); Eye 2.2 (2.7); Snout 1.7 (3.5); Maxillary 1.7 (3.5); Pectoral length 4.6; Pelvic length 4.8; Dorsal count XII, 16; Anal count II, 13; Scales 29; Gill-rakers 8.

DESCRIPTION: Body dark blue (bluish gray after death); upper head and back above lateral line scarlet, thickly flecked with black; dorsal spines solid scarlet; dorsal rays and anal dusky at base, the remainder translucent bluish; very large ocellus, larger than eye, at junction of dorsal spines and rays, consisting of a large, jet-black center, surrounded with a ring of turquoise, with a narrow outer frame of black. A series of turquoise spots, framed with black, scattered over head and body as follows: 2 between upper lip and upper eye; 5 surrounding eye; 3 on opercle; 8 in a line, from eye almost to first ocellus; 3 large ones on each side of top of head, one obliquely above and in front of eye, one above eye, one on nape; 5 in iris, upper two large and stronger and connecting the loral and dorsal lines; 2 at base of posterior dorsal rays; 2 at base of posterior anal rays.

There is a second ocellus, one-third as large as the dorsal one, on the upper peduncle; Iris, aside from the turquoise spots, golden.

DISTRIBUTION: The two which I saw but could not capture in Bermuda are the only ones ever recorded from that island. The colored plate which I had drawn from memory had in no particular to be changed when compared with a fresh specimen from the West Indies. The following is the distribution of this new species and of its most closely related known form, as we observed it in the West Indies:

	E. rubridorsalis	*E. leucostictus*
Union Island, Grenadines (Type locality)	Abundant	Absent
Tobago Cays, Grenadines	Common	Several seen
Antigua	Common	Common
Barbuda	Common	Common
Haiti	Absent	Abundant
Bermuda	Two seen	Abundant

Having no dynamite caps, and owing to the absence of tide-pools in the Leeward Islands, I was able to capture only two specimens of this new species, which however, although from different islands, three hundred miles apart, are identical in measurements, pattern and coloration.

We saw many, from two to three inches in length, always in pairs, and, as in other species of this genus, constantly on the defensive, attacking and driving away all intruders, large and small, from their chosen home.

There is no doubt that this is an adult coloration, distinctly marked, not a permanent color phase, not grading, sexually, emotionally or ontogenetically into any other phase. Both in haunts, habits, size and general pattern *rubridorsalis* offers an interesting comparison with *leucostictus*.

Grenada Sponge Goby

Gobiosoma chancei sp. nov.

(Fig. 17)

TYPE: *And only specimen, Antares Expedition, New York Zoological Society, No. 22. July 4th, 1932. Taken from a large, yellow sponge on a shallow reef in St. George's Bay, Grenada, B. W. I.*

MEASUREMENTS: Total length 47 mm.; Standard length 39 mm.; Depth 9 (4.3); Head 10.7 (3.6); Eye 2.5 (4.3); Snout 1.7 (6.3); Maxillary 4 (2.7); Dorsal VII–12; Anal 10.

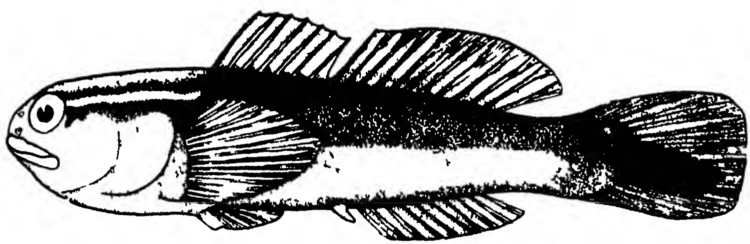

Fig 17 Grenada Sponge Goby, *Gobiosoma chancei* sp. nov
Drawing by Helen Tee-Van

COLOR: General body dark brown below, darkening into black above; entire lower center of caudal fin black; lips, chin and throat bright lemon yellow; iris greenish; a strong yellow line extending from the top of each eye, back along each side of the head, ending abruptly midway between the beginning of the first dorsal fin and the upper base of the pectoral. This line is bounded widely on each side with jet black.

COMPARISON: This species is closest to *Gobiosoma horsti* Metzelaar, differing chiefly in pattern, color and the relative positions of all the fins, as well as the absence of scales on the caudal peduncle. Briefly expressed, in *Gobiosoma chancei* the colored lateral line is short, not long, and it is yellow, not blue; the first dorsal fin arises behind, not before the pectoral base; the second dorsal arises in front of, not behind the anus; the pelvics are well developed, not minute, and they arise behind, not in front of the pectorals. There is no trace of scales, even on the peduncle or along the sides.

This species is named in honor of Colonel Edwin M. Chance to whose interest and generosity this West Indian expedition was due.

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BERMUDA OCEANOGRAPHIC EXPEDITIONS

1929—1930

INTRODUCTION*

By WILLIAM BEEBE

(Figs. 1-7 incl.)

I. FOREWORD

The idea of carrying on daily deep-sea trawling with a shore laboratory for a base occurred to me on July 15th, 1925, when I was establishing Station No. 100 on the *Arcturus*, a few miles south of Bermuda. I had not the slightest idea that four years later I should be located on the island of Nonsuch, then visible from the bridge, and with the same winch then in use, I would be trawling over this identical area.

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*Contribution, New York Zoological Society, Department of Tropical Research, No. 353.

Fig 1 Airplane view of Nonsuch Island showing laboratories and neighboring reefs
Photo by Capt Nelmes

The vibrations and other drawbacks to microscopic and similar laboratory work and the very great cost of an expedition like that of the *Arcturus* induced me to begin experiments. I found by several trips to the Hudson Gorge off New York City, that on an ordinary tug boat I could easily haul six one-metre nets at an extreme depth of 1400 fathoms, and that the resulting catches were as varied and rich, and came up in as good condition as those on the *Arcturus*[1]. Two short visits to Bermuda made me certain that this would form an excellent headquarters. Good fortune attended me, for on a picnic to Nonsuch with His Excellency, the late Governor Sir Louis Bols and the Honorable F. Goodwin Gosling, I was offered the use of the island with its excellent buildings if I cared to use it. Examination of the map showed that this was the most desirable place in Bermuda for my work. It was well isolated from the hotels and troublesome tourists, yet within easy reach of St. Georges; Castle Roads was a convenient passage for a vessel to the open sea, and a depth of 1000 fathoms was to be found only five miles off shore to the south.

I found that at St. Georges a sea-going tug, the *Gladisfen,* was available for charter at a reasonable price, and most important of all, when I had assembled all my plans and formulated them, two very great friends, Harrison Williams and Mortimer Schiff, offered to finance the expedition.

This was the evolution of the Bermuda Oceanographic Expedition of the New York Zoological Society.

II. Oceanographic Investigation near Bermuda

The waters of Bermuda have been visited by the vessels of some of the most important oceanographic expeditions. When I am ready to publish the total catch of deep-sea fish taken in the restricted area, I will summarize the hauls and other results of the other expeditions. Here I need only briefly to list the stations:

The *Challenger* in 1873 made twenty-seven Stations and Substations within one hundred miles of my trawling center.
The *Margrethe* in 1913 made three Stations.
The *Dana* in 1920 and 1922 made three Stations.
The *Arcturus* in 1925 made seven Stations.
The *Pawnee* in 1927 made two Stations.
The *Chance* in 1927 made two Stations.
The *Albatross* in 1929 made four Stations.

[1] Zoologica Vol. XII, Nos. 1; Zool. Soc. Bull. Vol. XXII, No. 2.

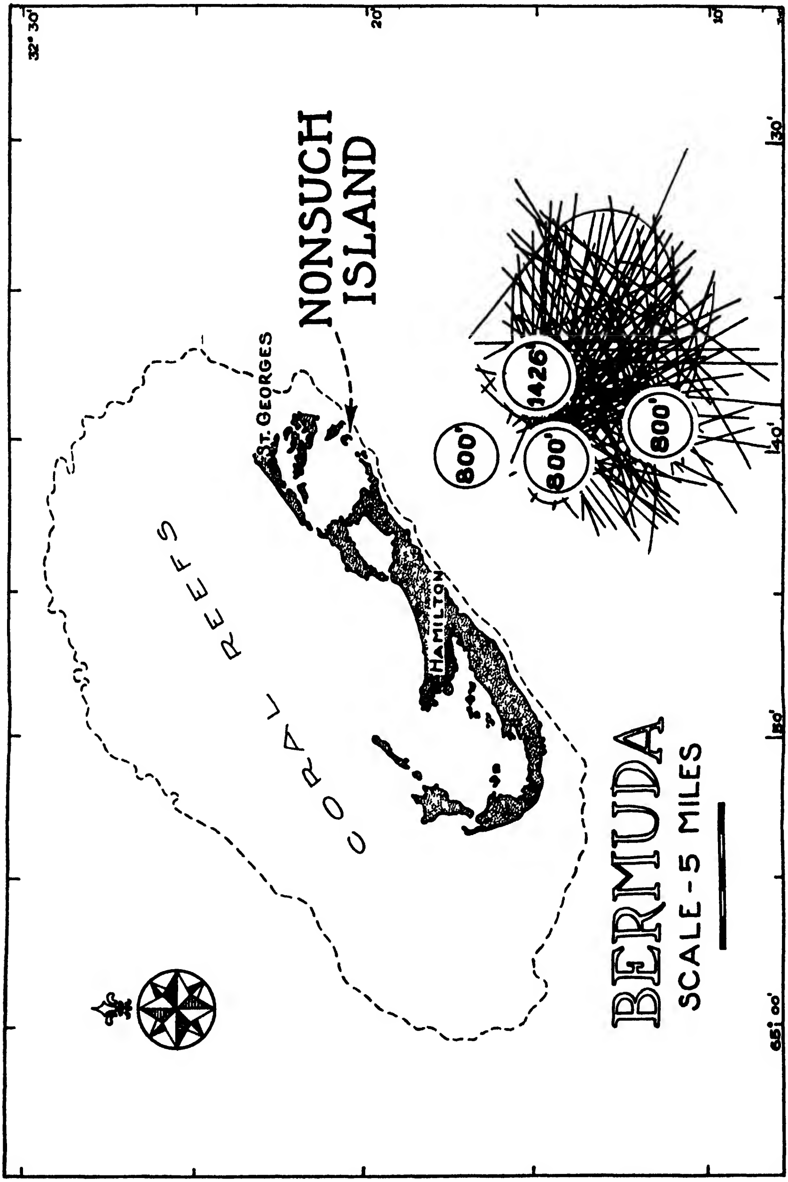


Fig. 2. Diagrammatic view showing Nonsuch Island, the area of trawling, and the location of four deep dives of the Bathysphere.

Tarleton Bean in 1906 in a list of fishes of Bermuda enumerates several deep-sea fish, apparently washed ashore.

III. Collecting Apparatus on the *Gladisfen*

The *Gladisfen* is a sturdy tug ninety-three feet over all. It was found possible to fit her with satisfactory trawling, dredging and sounding apparatus without altering any of her structure. On the forward deck, amidships, just forward of the pilot house was installed the sounding machine, the wire leading to a pivoting yard arm which swung overboard at right angles to the tug when in action.

Immediately aft of the towing bitts was placed the smaller winch or towing engine with its load of 15,000 feet of quarter inch wire. This cable led directly astern over a sheave mounted on steel davits, projecting so far overboard that the descending wire hung clear of the rudder. This gave room for a suspended metre-wheel, for a two-man, block-and-tackle reeling arrangement, and a man to stand and oil the in-coming cable. Instead of freeing the wire of superfluous water by banging it with clubs as we did on the *Arcturus,* two men who attended to the attachment and unfastening of the weight and nets, let the wire run through a mass of sacking with which they gripped the cable.

Both the sounding machine and the towing engine are described by Mr. Tee-Van in the account of the operation and equipment of the *Arcturus.* (Zoologica Vol. VIII, No. 2.)

IV. Trawling Accidents

While it is the custom to record only the successes of an expedition, it has seemed only fair to tell very briefly of the accidents. During the two seasons of work and the hauling of 976 nets we lost nineteen nets by accident, as follows:

3—Lost overboard and in propellor.
3—Ripped from too long use.
7—Torn away when bottom was touched.
1—Torn away from excess speed.
5—Lost from breaking of sister hooks.

Besides this we touched bottom accidently four times without doing any harm to the nets; six nets became entangled or wound about the cable or brass attaching balls, resulting in no catch, and finally two brass balls were lost from the breaking of their hinges without the loss of the nets.

On July 16, 1929, the side of the drum of the towing engine gave way. About a third of the circumference went, the central

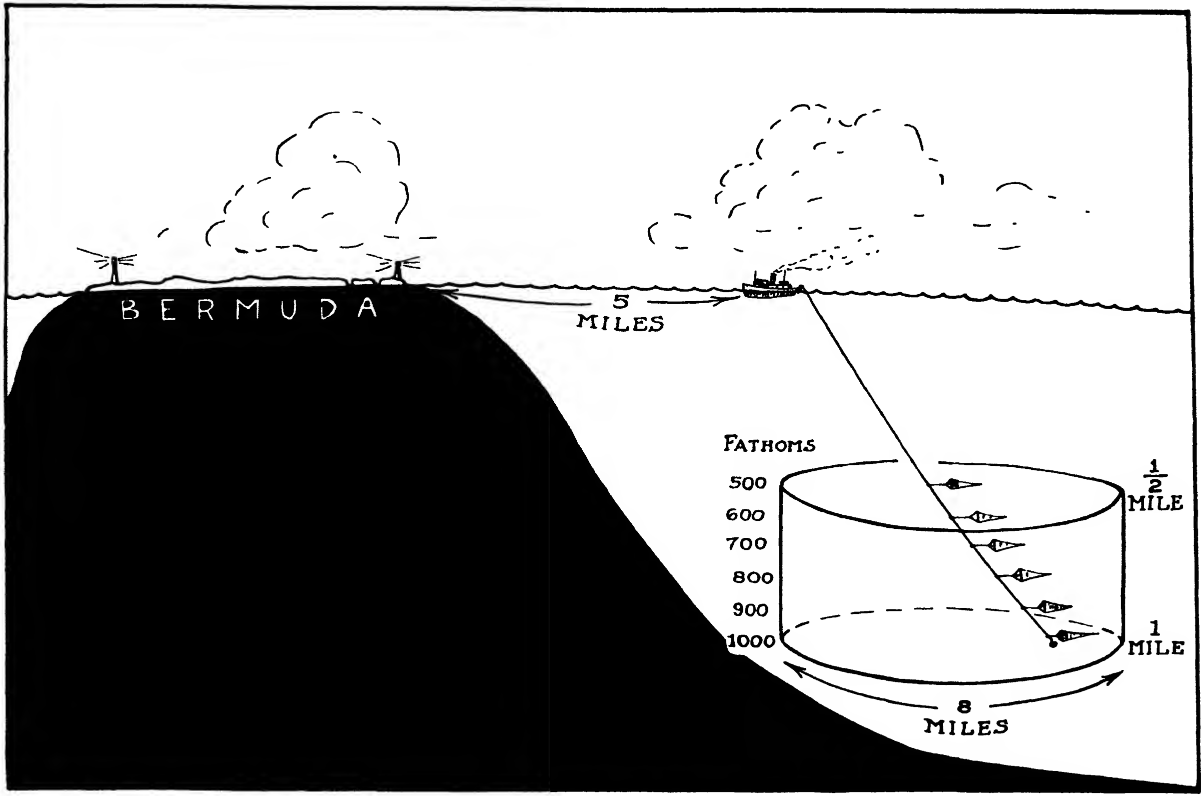


Fig. 3. Diagrammatic section showing the tug and general position of the cylindrical trawling area.

portion down to the core. There was no sign of a break before it actually shattered, and no sound when it collapsed, the piece of metal merely dropping off. Fortunately the collapsed rows of cable did not prevent the operation of the winch, so the wire and nets were saved. The break was repaired in the Government Navy Yard.

Exactly one year later, on July 16, 1930, the reinforced side of the drum again broke, this time so badly that a new drum had to be ordered and installed.

V. Method of Work

Our routine of deep sea work varies little from day to day. The *Gladisfen* with her native Bermudian crew of five, steams out from St. Georges, skirts the west shore of Castle Harbor and ties up at her buoy near our wharf about 7 A. M. Usually before her warning whistle blows the two or three members of my staff due for sea duty that day are on their way with racks of mason jars, lunch, extra nets, pails, shark hooks and bait. They go out in our fast launch the *Skink* and immediately the tug steams out through Castle Roads to the open sea. The succeeding course depends on the wind and currents, but it is usually south or south-west.

When at the rim of my imaginary cylinder, as indicated by the relative position of Gibbs Hill and St. David's Lighthouses, the tug is slowed down and the weight is put overboard. One after another, six one-meter nets are attached at equal distances apart, and then sufficient cable paid out to lower the first net to 1000 fathoms, bringing the upper to 500 fathoms.

Then begins a four or five hour vigil, watch being kept on engine revolutions, winch, wire, angle of the wire both lateral and vertical, as well as for any sign of change in the weather affecting wind, current or wave. The surface is scanned for sharks, dolphins, squids, or other creatures, the air watched for birds, and passing sargassum weed is netted and examined for fish and rare invertebrates.

Occasionally in a flat calm, when weed is abundant, a boat with outboard motor is launched and I have had great sport catching young flying-fish on the wing with a butterfly net.

After as long as possible a haul, the trawling crew is assembled, steam is gotten up, and slowly the cable is reeled in. Two men take their place at the very stern watching the wire and wiping off excess water, another oils the cable as it goes on the reel, two more handle a horizontal block and tackle, guiding the cable back and forth so that it is spooled evenly.

Fig 4 Tug *Gladisfen* used in all trawling work of the Bermuda Oceanographic Expedition

Fig 5 Metre net, sheave, wire and winch on the aft deck of the *Gladisfen*

Fig. 6 Clock-work mechanism and recording sheet of the Bathygraph, used for indicating the entire course of a net in trawling.

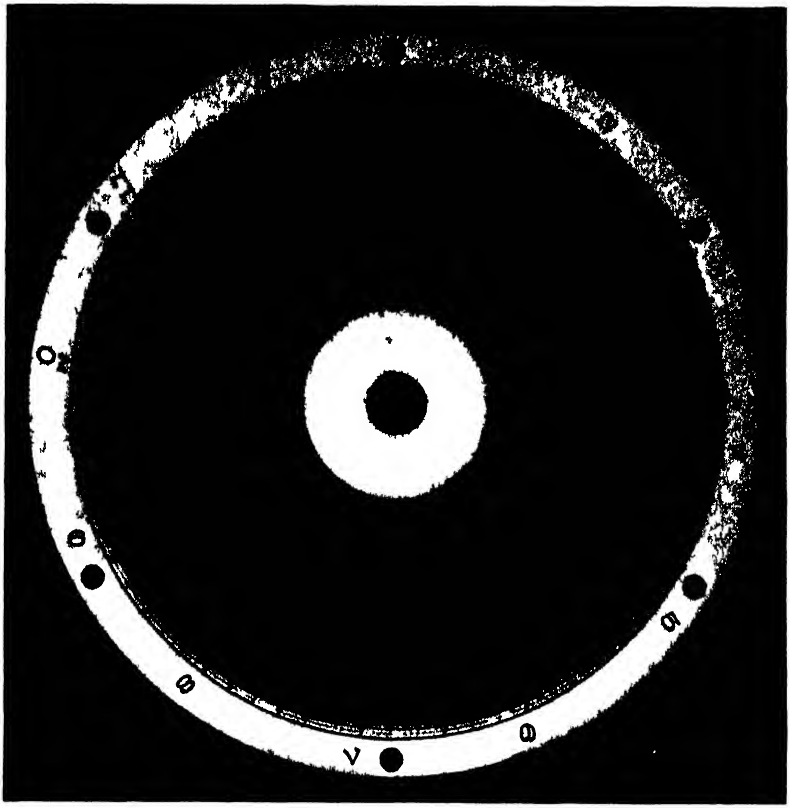


Fig 7 Record of the Bathygraph showing successively deeper temperature and water sample records and the course of a thousand fathom trawl continued for two hours

When the first net appears it is carefully detached, carried into the aft cabin and the mason jar cut free, labelled and placed in its rack. The lower part of the net is then washed for whatever organisms may be caught in it. The entire net is washed and passed to the upper deck to dry. A rough assorting takes place. All large living fish are placed by themselves in a pail with ice. Very delicate forms are placed in formaline. After the last net is aboard the tug is headed full speed for Nonsuch.

At the wharf the jars are carried gently by hand to the laboratory and emptied into individual pans. A finer, thorough assorting now takes place. I pass all new forms showing bright colors to the artist who makes quick color notes; others are taken by the photographer. The great majority are sorted out,

catalogued by those in charge of the vertebrates and the invertebrates, and notes of evanescent color, form and movement made before preservation. The rare living fish and squids are put into the refrigerators, for further study in the morning.

VI. Brief Narrative of the Expedition

An account of the expedition will be given in a future number of Zoologica in full detail. Here it is only necessary to present the more salient facts.

The Expeditions of 1929 and 1930 are known as the 12th and 13th Expeditions of the Department of Tropical Research of the New York Zoological Society, under the Directorship of Dr. William Beebe. The First was in the field from March 13th to October 22nd, 1929, and the Second from April 11th to October 30th, 1930.

The personnel for the two years was as follows:

Director—William Beebe
General Assistant—John Tee-Van
Technical Associate—Gloria Hollister

Scientific Associates

William K. Gregory
Charles J. Fish
Marie P. Fish
E. Newton Harvey
Otis Barton
William Merriam

Laboratory Assistants

P. Boyden
Jocelyn Crane
Margaret Elliott
Alice Wright
Virginia Ziegler

Artists

E. M. Bostelmann
G. Bostelmann
Helen Tee-Van
Llewellyn Miller

Photographers

J. Connery
R. Whitelaw

Field Assistants

Arthur Tucker, Government Care-taker of Nonsuch.
H. Barnes
P. Bass
J. Cannon
P. Crouch
J. Guernsey
A. Hollis
P. Jackson
S. von Hallberg

The chief object of the expedition may be said to be the study of the fish of Bermuda in the widest sense,— those of the tide-pools and shallow waters, of the surface of the ocean, of the mid-waters, and of the abyssmal depths.

In actual practice this divided itself into two divisions—the fish fauna of the shallow waters and those of the ocean deeps. The first we caught and studied by means of hooks and lines, nets, seines, traps, poisons, dynamite, water glasses, glass-bottomed boats, diving helmets and, in the case of adult flying fish, even shot-guns. The fish of the second division were taken with nets, trawls and dredges, and were observed through the quartz windows of the bathysphere down to a depth of a quarter of a mile.

The two most important accessory aids used for the first time on the expeditions were a depth recording gauge of great accuracy which gave complete records of nets down to one thousand fathoms, and the all-steel bathysphere in which Mr. Barton and I were able to descend easily, observe clearly and ascend safely from depths down to 1426 feet. A detailed account of this will be found in the Zoological Society's Bulletin, Volume XXXIII, Number 6, and will be dealt with again in future Zoologicas.

The total cost of each expedition was $33,000 and of this $66,000 Mr. Harrison Williams and Mr. Mortimer Schiff contributed all but $10,000. This latter sum was divided between Burt Massee, F. C. Walcott, Ernest F. Weir, Edna Albert, W. E. Boeing, Herbert L. Satterlee and William Delano.

VII. Locality Chosen for Study

The following 976 nets were hauled through a definite area of open ocean, south of Bermuda. This area is roughly circular, eight miles in diameter, and the great majority of the nets were drawn at 500, 600, 700, 800, 900, and 1000 fathoms.

Observations by means of the two light-houses, Gibbs Hill and St. Davids, made it possible to get accurate sights at the beginning and the end of each individual haul. Soundings give a clear idea of the contour of the bottom of this oceanic cylinder. These, together with physical results of temperature, salinity, oxygen content, etc., will be tabulated at the end of the third year of study.

To give the location with more exactness;—the eight mile circle under consideration has its center at 32° 12′ North Latitude, and 64° 36′ West Longitude, which point is 160 degrees by

the compass, or South-south-east of Nonsuch. Its horizontal boundaries are as follows;—

Northern rim—32° 16′ North Latitude.
Southern rim—32° 8′ North Latitude.
Eastern rim—64° 31′ 20″ West Longitude.
Western rim—64° 40′ 40″ West Longitude.

At no place is its bottom less than 1000 fathoms in depth. It slopes rather rapidly in the northeastern corner to 1357 fathoms, and along its southern border is between 1400 and 1500 fathoms deep. My first deep dive of 803 feet was in the southwest sector, and the 1426 foot dive was on the northern rim.

Zoologica Vol. XIII, No. 2

BERMUDA OCEANOGRAPHIC EXPEDITIONS

1929—1930

INDIVIDUAL NETS AND DATA*

By WILLIAM BEEBE

*Contribution, New York Zoological Society, Department of Tropical Research, No. 354.

VIII. Individual Nets and Data

Nets by vertical distribution—1929

	April	*May*	*June*	*July*	*August*	*Sept.*	*Oct.*	*Total*
Surface	7	5	4	1	1	16	..	34
100	..	2	..	..	..	2	..	4
200	1	3	..	..	..	2	..	6
300	1	4	..	..	..	2	..	7
400	3	6	..	..	4	2	..	15
500	11	9	15	20	6	14	..	75
600	13	15	15	15	6	13	..	77
700	6	13	16	17	6	18	..	76
800	5	11	15	19	7	18	..	75
900	6	15	16	16	6	19	..	78
1000	3	5	15	20	15	20	..	78
1100	..	1	1	..	1	..	..	3
TOTAL	56	89	97	108	52	126	..	528

Nets by vertical distribution—1930

Surface	7	21	12	5	1	4	2	52
100	..	1	1	..	..	3	1	6
200	..	2	1	..	..	3	..	6
300	..	8	1	1	..	6	..	16
400	..	10	4	1	..	10	..	25
500	..	23	4	9	..	21	..	57
600	..	22	2	5	6	22	..	57
700	..	9	16	9	1	21	..	56
800	..	9	17	9	2	20	..	57
900	..	7	19	8	2	21	..	57
1000	..	5	20	11	..	21	..	57
1100	..	1	..	..	..	..	..	1
1200	..	1	..	..	..	..	..	1
TOTAL	7	119	97	58	12	152	3	448

Surface	86
100	10
200	12
300	23
400	40
500	132
600	134
700	132
800	132
900	135
1000	135
1100	4
1200	1
	976

INDIVIDUAL NETS AND DATA

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1929	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Apr.		H	M					
1	Metre	400	732	3	10:56AM	1	45	SE	Cloudy	N	5	Rough
2	Metre	500	914	3	10:56	1	45	SE	Cloudy	N	5	Rough
3	Metre	600	1097	3	10:56	1	45	SE	Cloudy	N	5	Rough
4	Metre	400	732	5	1:15PM	1	30	SE	Clear	SW	2	Swell
5	Metre	500	914	5	1:15	1	30	SE	Clear	SW	2	Swell
6	Metre	600	1097	5	1:15	1	30	SE	Clear	SW	2	Swell
7	½Metre	0	0	9	10:36AM	1	54	SSE	Clear	NW	4	Choppy
8	Metre	200	366	9	10:36	1	54	SSE	Clear	NW	4	Choppy
9	Metre	300	549	9	10:36	1	54	SSE	Clear	NW	4	Choppy
10	Metre	400	732	9	10:36	1	54	SSE	Clear	NW	4	Choppy
11	Metre	500	914	9	10:36	1	54	SSE	Clear	NW	4	Choppy
12	Metre	500	914	9	10:36	1	54	SSE	Clear	NW	4	Choppy
13	Metre	600	1097	9	10:36	1	54	SSE	Clear	NW	4	Choppy
14	½Metre	0	0	12	9:25	4	05	S to E	Clear	S	3	Swell
15	Metre	500	914	12	9:25	4	05	S to E	Clear	S	3	Swell
16	Metre	600	1097	12	9:25	4	05	S to E	Clear	S	3	Swell
17	Metre	600	1097	12	9:25	4	05	S to E	Clear	S	3	Swell
18	Metre	700	1280	12	9:25	4	05	S to E	Clear	S	3	Swell
19	½Metre	0	0	14	7:25PM		30	N and S	Cloudy moonlight	SE	0	Calm
20	½Metre	0	0	15	9:13AM	4	17	E to N	Overcast	SE	3	Choppy
21	Metre	500	914	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
22	Metre	600	1097	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
23	Metre	600	1097	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
24	Metre	700	1280	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
25	Metre	800	1463	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
26	Metre	900	1646	15	9:13	4	17	E to N	Overcast	SE	3	Choppy
27	Metre	500	914	20	9:45	2	55	S and E	Clear	NW	4	Swell
28	Metre	500	914	20	9:45	2	55	S and E	Clear	NW	4	Swell
29	Metre	500	914	20	9:45	2	55	S and E	Clear	NW	4	Swell
30	Metre	600	1097	20	9:45	2	55	S and E	Clear	NW	4	Swell
31	Metre	500	914	24	9:54	3	36	SSW	Clear	NE	1	Swell
32	Metre	600	1097	24	9:54	3	36	SSW	Clear	NE	1	Swell
33	Metre	600	1097	24	9:54	3	36	SSW	Clear	NE	1	Swell
34	Metre	700	1280	24	9:54	3	36	SSW	Clear	NE	1	Swell
35	Metre	800	1463	24	9:54	3	36	SSW	Clear	NE	1	Swell
36	Metre	900	1646	24	9:54	3	36	SSW	Clear	NE	1	Swell
37	½Metre	0	0	24	9:54	3	36	SSW	Clear	NE	1	Swell
38	½Metre	0	0	25	10:08	4	0	S and W	Clear	ESE	1	Rough
39	Metre	600	1097	25	10:08	4	0	S and W	Clear	ESE	1	Rough
40	Metre	700	1280	25	10:08	4	0	S and W	Clear	ESE	1	Rough
41	Metre	800	1463	25	10:08	4	0	S and W	Clear	ESE	1	Rough
42	Metre	900	1646	25	10:08	4	0	S and W	Clear	ESE	1	Rough
43	Metre	900	1646	25	10:08	4	0	S and W	Clear	ESE	1	Rough
44	Metre	1000	1829	25	10:08	4	0	S and W	Clear	ESE	1	Rough
45	Metre	500	914	29	10:14	4	0	E to NE	Overcast	SW	3	Rough
46	Metre	600	1097	29	10:14	4	0	E to NE	Overcast	SW	3	Rough
47	Metre	600	1097	29	10:14	4	0	E to NE	Overcast	SW	3	Rough
48	Metre	700	1280	29	10:14	4	0	E to NE	Overcast	SW	3	Rough
49	Metre	800	1463	29	10:14	4	0	E to NE	Overcast	SW	3	Rough
50	Metre	900	1646	29	10:14	4	0	E to NE	Overcast	SW	3	Rough

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				Apr.								
51	½Metre	0	0	29	12:00M	2	0	E to NE	Overcast	SW	3	Rough
52	Metre	700	1280	30	9:43AM	4	2	SW	Squally	NE	2	Swell
53	Metre	800	1463	30	9:43	4	2	SW	Squally	NE	2	Swell
54	Metre	900	1646	30	9:43	4	2	SW	Squally	NE	2	Swell
55	Metre	1000	1829	30	9:43	4	2	SW	Squally	NE	2	Swell
56	Metre	1000	1829	30	9:43	4	2	SW	Squally	NE	2	Swell
				May								
57	½Metre	0	0	1	8:55PM		20	N and S	Starlight	SW	2	Choppy
58	Metre	500	914	3	9:57AM	4	4	SE	Overcast	SSW	2	Choppy
59	Metre	500	914	3	9:57	4	4	SE	Overcast	SSW	2	Choppy
60	Metre	500	914	3	9:57	4	4	SE	Overcast	SSW	2	Choppy
61	Metre	600	1097	3	9:57	4	4	SE	Overcast	SSW	2	Choppy
62	Metre	600	1097	3	9:57	4	4	SE	Overcast	SSW	2	Choppy
63	Metre	600	1097	3	9:57	4	4	SE	Overcast	SSW	2	Choppy
64	Metre	600	1097	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
65	Metre	700	1280	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
66	Metre	800	1463	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
67	Metre	900	1646	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
68	Metre	1000	1820	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
69	Metre	1000	1820	4	10:20	3	45	SE to NW	Overcast	E	1	Choppy
70	½Metre	0	0	4	11:40	2	10	SE to NW	Overcast	E	1	Choppy
71	Metre	600	1097	6	10:24	3	45	SE circle	Clear	S	1	Swell
72	Metre	600	1097	6	10:24	3	45	SE circle	Clear	S	1	Swell
73	Metre	700	1280	6	10:24	3	45	SE circle	Clear	S	1	Swell
74	Metre	700	1280	6	10:24	3	45	SE circle	Clear	S	1	Swell
75	Metre	700	1280	6	10:24	3	45	SE circle	Clear	S	1	Swell
76	Metre	800	1463	6	10:24	3	45	SE circle	Clear	S	1	Swell
77	½Metre	0	0	6	12:30PM	1	37	SE circle	Clear	S	1	Swell
78	Metre	600	1097	8	7:25AM	6	40	SE	Squally	W	2	Choppy
79	Metre	700	1280	8	7:25	6	40	SE	Squally	W	2	Choppy
80	Metre	800	1463	8	7:25	6	40	SE	Squally	W	2	Choppy
81	Metre	900	1646	8	7:25	6	40	SE	Squally	W	2	Choppy
82	Metre	900	1646	8	7:25	6	40	SE	Squally	W	2	Choppy
83	Metre	1000	1829	8	7:25	6	40	SE	Squally	W	2	Choppy
84	Metre	100	183	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
85	Metre	200	366	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
86	Metre	300	549	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
87	Metre	400	732	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
88	Metre	500	914	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
89	Metre	600	1097	10	9:31	4	34	SE to E	Clear	WSW	2	Choppy
90	Metre	200	366	11	9:35AM	4	30	W to SW	Squally	NE	4	Rough
91	Metre	300	549	11	9:35	4	30	W to SW	Squally	NE	4	Rough
92	Metre	400	732	11	9:35	4	30	W to SW	Squally	NE	4	Rough
93	Metre	500	914	11	9:35	4	30	W to SW	Squally	NE	4	Rough
94	Metre	600	1097	11	9:35	4	30	W to SW	Squally	NE	4	Rough
95	Metre	700	1280	11	9:35	4	30	W to SW	Squally	NE	4	Rough
96	½Metre	0	0	11	12:00	2	0	W to SW	Squally	NE	4	Rough
97	Metre	300	549	14	10:35	3	0	SE to W	Clear	ENE	1	Swell
98	Metre	400	732	14	10:35	3	0	SE to W	Clear	ENE	1	Swell
99	Metre	500	914	14	10:35	3	0	SE to W	Clear	ENE	1	Swell
100	Metre	600	1097	14	10:35	3	0	SE to W	Clear	ENE	1	Swell

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				May								
101	Metre	700	1280	14	10:35AM	3	0	SE to W	Clear	ENE	1	Swell
102	Metre	800	1463	14	10:35	3	0	SE to W	Clear	ENE	1	Swell
103	Metre	600	1097	15	9:47	4	16	NE to E	Clear	S	2	Swell
104	Metre	700	1280	15	9:47	4	16	NE to E	Clear	S	2	Swell
105	Metre	800	1453	15	9:47	4	16	NE to E	Clear	S	2	Swell
106	Metre	900	1646	15	9:47	4	16	NE to E	Clear	S	2	Swell
107	Metre	1000	1829	15	9:47	4	16	NE to E	Clear	S	2	Swell
108	Metre	1100	2012	15	9:47	4	16	NE to E	Clear	S	2	Swell
109	Metre	600	1097	16	9:31	4	34	S to SE	Clear	W	1	Calm
110	Metre	700	1280	16	9:31	4	34	S to SE	Clear	W	1	Calm
111	Metre	700	1280	16	9:31	4	34	S to SE	Clear	W	1	Calm
112	Metre	800	1463	16	9:31	4	34	S to SE	Clear	W	1	Calm
113	Metre	800	1463	16	9:31	4	34	S to SE	Clear	W	1	Calm
114	Metre	900	1646	16	9:31	4	34	S to SE	Clear	W	1	Calm
115	Metre	400	732	18	9:39	4	1	S to E	Clear	SW	1	Calm
116	Metre	900	1646	18	9:39	4	1	S to E	Clear	SW	1	Calm
117	Metre	900	1646	18	9:39	4	1	S to E	Clear	SW	1	Calm
118	Metre	900	1646	18	9:39	4	1	S to E	Clear	SW	1	Calm
119	Metre	900	1646	18	9:39	4	1	S to E	Clear	SW	1	Calm
120	Metre	900	1646	18	9:39	4	1	S to E	Clear	SW	1	Calm
121	Metre	600	1097	25	9:45	2	45	SSE	Squally	SW	2	Choppy
122	Metre	700	1280	25	9:45	2	45	SSE	Squally	SW	2	Choppy
123	Metre	800	1463	25	9:45	2	45	SSE	Squally	SW	2	Choppy
124	2Metre	900	1646	25	9:45	2	45	SSE	Squally	SW	2	Choppy
125	Metre	900	1646	25	9:45	2	45	SSE	Squally	SW	2	Choppy
126	Metre	100	183	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
127	Metre	200	366	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
128	Metre	300	549	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
129	Metre	400	732	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
130	Metre	500	914	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
131	Metre	800	1463	27	9:30	4	40	ESE to W	Clear	NE	2	Swell
132	Metre	400	732	28	9:20	3	15	SSE	Cloudy	SE	2	Rough
133	Metre	500	914	28	9:20	3	15	SSE	Cloudy	SE	2	Rough
134	½Metre	0	0	28	8:40PM		20	N and S	Starlight	SE	2	Choppy
135	Metre	600	1097	30	9:55AM	4	5	SSW	Overcast	E	2	Choppy
136	Metre	700	1280	30	9:55	4	5	SSW	Overcast	E	2	Choppy
137	Metre	800	1463	30	9:55	4	5	SSW	Overcast	E	2	Choppy
138	Metre	900	1646	30	9:55	4	5	SSW	Overcast	E	2	Choppy
139	1 Dia.	900	1646	30	9:55	4	5	SSW	Overcast	E	2	Choppy
140	Metre	500	914	31	10:00	4	0	S	Squally	S	3	Choppy
141	Metre	600	1097	31	10:00	4	0	S	Squally	S	3	Choppy
142	Metre	700	1280	31	10:00	4	0	S	Squally	S	3	Choppy
143	Metre	800	1463	31	10:00	4	0	S	Squally	S	3	Choppy
144	Metre	900	1646	31	10:00	4	0	S	Squally	S	3	Choppy
145	Metre	1000	1829	31	10:00	4	0	S	Squally	S	3	Choppy
				June								
146	Metre	500	914	1	9:20	4	0	S	Clear	W	2	Swell
147	Metre	600	1097	1	9:20	4	0	S	Clear	W	2	Swell
148	Metre	700	1280	1	9:20	4	0	S	Clear	W	2	Swell
149	Metre	800	1463	1	9:20	4	0	S	Clear	W	2	Swell
150	Metre	900	1646	1	9:20	4	0	S	Clear	W	2	Swell

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				June								
151	Metre	1000	1829	1	9:20AM	4	0	S	Clear	W	2	Swell
152	½Metre	0	0	8	10:20	3	45	SxW	Clear	SE	2	Swell
153	Metre	700	1280	8	10:20	3	45	SxW	Clear	SE	2	Swell
154	Metre	800	1463	8	10:20	3	45	SxW	Clear	SE	2	Swell
155	Metre	900	1646	8	10:20	3	45	SxW	Clear	SE	2	Swell
156	Metre	1000	1829	8	10:20	3	45	SxW	Clear	SE	2	Swell
157	2Metre	1100	2012	8	10:20	3	45	SxW	Clear	SE	2	Swell
158	Metre	500	914	12	9:26	4	05	SE	Clear	SW	2	Choppy
159	Metre	600	1097	12	9:26	4	05	SE	Clear	SW	2	Choppy
160	Metre	700	1280	12	9:26	4	05	SE	Clear	SW	2	Choppy
161	Metre	800	1463	12	9:26	4	05	SE	Clear	SW	2	Choppy
162	Metre	900	1646	12	9:26	4	05	SE	Clear	SW	2	Choppy
163	Metre	1000	1829	12	9:26	4	05	SE	Clear	SW	2	Choppy
164	Metre	500	914	14	9:45	4	05	SE	Clear	S	1	Swell
165	Metre	600	1097	14	9:45	4	05	SE	Clear	S	1	Swell
166	Metre	700	1280	14	9:45	4	05	SE	Clear	S	1	Swell
167	Metre	800	1463	14	9:45	4	05	SE	Clear	S	1	Swell
168	Metre	900	1646	14	9:45	4	05	SE	Clear	S	1	Swell
169	2Metre	1000	1829	14	9:45	4	05	SE	Clear	S	1	Swell
170	Metre	500	914	15	9:46	4	02	SW	Clear	ESE	1	Swell
171	Metre	600	1097	15	9:46	4	02	SW	Clear	ESE	1	Swell
172	Metre	700	1280	15	9:46	4	02	SW	Clear	ESE	1	Swell
173	Metre	800	1463	15	9:46	4	02	SW	Clear	ESE	1	Swell
174	Metre	900	1646	15	9:46	4	02	SW	Clear	ESE	1	Swell
175	Metre	1000	1829	15	9:46	4	02	SW	Clear	ESE	1	Swell
176	Metre	500	914	17	9:28	4	02	SW	Clear	WxN	2	Swell
177	Metre	600	1097	17	9:28	4	02	SW	Clear	WxN	2	Swell
178	Metre	700	1280	17	9:28	4	02	SW	Clear	WxN	2	Swell
179	Metre	800	1463	17	9:28	4	02	SW	Clear	WxN	2	Swell
180	Metre	900	1646	17	9:28	4	02	SW	Clear	WxN	2	Swell
181	2Metre	1000	1829	17	9:28	4	02	SW	Clear	WxN	2	Swell
182	Metre	500	914	18	9:35	4	0	SE	Clear	NW	2	Choppy
183	Metre	600	1097	18	9:35	4	0	SE	Clear	NW	2	Choppy
184	Metre	700	1280	18	9:35	4	0	SE	Clear	NW	2	Choppy
185	Metre	900	1646	18	9:35	4	0	SE	Clear	NW	2	Choppy
186	2Metre	1000	1829	18	9:35	4	0	SE	Clear	NW	2	Choppy
187	Metre	500	914	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
188	Metre	600	1097	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
189	Metre	700	1280	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
190	Metre	800	1463	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
191	Metre	900	1646	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
192	2Metre	1000	1829	19	9:50	4	10	SxE	Clear	WxN	2	Moderate
193	Metre	500	914	20	9:41	4	03	SE to E	Clear	W	3	Rough
194	Metre	600	1097	20	9:41	4	03	SE to E	Clear	W	3	Rough
195	Metre	700	1280	20	9:41	4	03	SE to E	Clear	W	3	Rough
196	Metre	800	1463	20	9:41	4	03	SE to E	Clear	W	3	Rough
197	Metre	900	1646	20	9:41	4	03	SE to E	Clear	W	3	Rough
198	2Metre	1000	1829	20	9:41	4	03	SE to E	Clear	W	3	Rough
199	Metre	500	914	21	9:47	4	03	SxE	Clear	WSW	4	Moderate
200	Metre	600	1097	21	9:47	4	03	SxE	Clear	WSW	4	Moderate
201	Metre	700	1280	21	9:47	4	03	SxE	Clear	WSW	4	Moderate

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				June								
202	Metre	800	1463	21	9:47AM	4	03	SxE	Clear	WSW	4	Moderate
203	Metre	900	1646	21	9:47	4	03	SxE	Clear	WSW	4	Moderate
204	Metre	1000	1829	21	9:47	4	03	SxE	Clear	WSW	4	Moderate
205	Metre	500	914	22	9:50	3	0	SxE	Squally	SSE	4	Rough
206	Metre	600	1097	22	9:50	3	0	SxE	Squally	SSE	4	Rough
207	Metre	700	1280	22	9:50	3	0	SxE	Squally	SSE	4	Rough
208	Metre	800	1463	22	9:50	3	0	SxE	Squally	SSE	4	Rough
209	Metre	900	1646	22	9:50	3	0	SxE	Squally	SSE	4	Rough
210	Metre	1000	1829	22	9:50	3	0	SxE	Squally	SSE	4	Rough
211	Metre	500	914	24	10:05	4	05	SxE	Clear	S	3	Moderate
212	Metre	600	1097	24	10:25	4	05	SxE	Clear	S	3	Moderate
213	Metre	700	1280	24	10:25	4	05	SxE	Clear	S	3	Moderate
214	Metre	800	1463	24	10:25	4	05	SxE	Clear	S	3	Moderate
215	Metre	900	1646	24	10:25	4	05	SxE	Clear	S	3	Moderate
216	Metre	1000	1829	24	10:25	4	05	SxE	Clear	S	3	Moderate
217	Metre	500	914	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
218	Metre	600	1097	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
219	Metre	700	1280	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
220	Metre	800	1463	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
221	Metre	900	1646	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
222	Metre	1000	1829	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
223	¼Metre	0	0	25	9:39	4	01	SSE to E	Clear	SSW	3	Swell
224	Metre	500	914	27	9:30PM	8	0	E to N	Moonlight	SW	2	Calm
225	Metre	600	1097	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
226	Metre	700	1280	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
227	Metre	800	1463	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
228	Metre	900	1646	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
229	Metre	1000	1829	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
230	¼Metre	0	0	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
231	¼Metre	0	0	27	9:30	8	0	E to N	Moonlight	SW	2	Calm
232	Metre	500	914	28	9:45AM	4	10	SSE	Squally	WxN	4	Rough
233	Metre	600	1097	28	9:45	4	10	SSE	Squally	WxN	4	Rough
234	Metre	700	1280	28	9 45	4	10	SSE	Squally	WxN	4	Rough
235	Metre	800	1463	28	9:45	4	10	SSE	Squally	WxN	4	Rough
236	Metre	900	1646	28	9:45	4	10	SSE	Squally	WxN	4	Rough
237	Metre	1000	1829	28	9:45	4	10	SSE	Squally	WxN	4	Rough
238	Metre	500	914	29	9:54	3	20	SE	Squally	SW	4	Rough
239	Metre	600	1097	29	9:54	3	20	SE	Squally	SW	4	Rough
240	Metre	700	1280	29	9:54	3	20	SE	Squally	SW	4	Rough
241	Metre	800	1463	29	9:54	3	20	SE	Squally	SW	4	Rough
242	Metre	900	1646	29	9:54	3	20	SE	Squally	SW	4	Rough
				July								
243	Metre	600	1097	1	12:18PM	2	02	ESE	Squally	W	4	Rough
244	Metre	700	1280	1	12:18	2	02	ESE	Squally	W	4	Rough
245	Metre	800	1463	1	12:18	2	02	ESE	Squally	W	4	Rough
246	Metre	900	1646	1	12:18	2	02	ESE	Squally	W	4	Rough
247	Metre	1000	1829	1	12:18	2	02	ESE	Squally	W	4	Rough
248	Metre	500	914	4	9:40AM	4	02	ESE	Overcast	SW	3	Swell
249	Metre	600	1097	4	9:40	4	02	ESE	Overcast	SW	3	Swell
250	Metre	700	1280	4	9:40	4	02	ESE	Overcast	SW	3	Swell
251	Metre	800	1463	4	9:40	4	02	ESE	Overcast	SW	3	Swell

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres	July		H	M			Direction	Force	
252	Metre	900	1646	4	9:40AM	4	02	ESE	Overcast	SW	3	Swell
253	Metre	1000	1829	4	9:40	4	02	ESE	Overcast	SW	3	Swell
254	Metre	500	914	5	9:32	4	0	SExE	Clear	SSW	2	Calm
255	Metre	600	1097	5	9:32	4	0	SExE	Clear	SSW	2	Calm
256	Metre	700	1280	5	9:32	4	0	SExE	Clear	SSW	2	Calm
257	Metre	800	1463	5	9:32	4	0	SExE	Clear	SSW	2	Calm
258	Metre	900	1646	5	9:32	4	0	SExE	Clear	SSW	2	Calm
259	Metre	1000	1829	5	9:32	4	0	SExE	Clear	SSW	2	Calm
260	Metre	500	914	6	9:45	4	0	SW	Clear	SW	2	Calm
261	Metre	600	1097	6	9:45	4	0	SW	Clear	SW	2	Calm
262	Metre	700	1280	6	9:45	4	0	SW	Clear	SW	2	Calm
263	Metre	800	1463	6	9:45	4	0	SW	Clear	SW	2	Calm
264	Metre	900	1646	6	9:45	4	0	SW	Clear	SW	2	Calm
265	2Metre	1000	1829	6	9:45	4	0	SW	Clear	SW	2	Calm
266	Metre	500	914	8	10:16	4	0	SExS	Clear	SE	1	Swell
267	Metre	600	1097	8	10:16	4	0	SExS	Clear	SE	1	Swell
268	Metre	700	1280	8	10:16	4	0	SExS	Clear	SE	1	Swell
269	Metre	800	1463	8	10:16	4	0	SExS	Clear	SE	1	Swell
270	Metre	900	1646	8	10:16	4	0	SExS	Clear	SE	1	Swell
271	2Metre	1000	1829	8	10:16	4	0	SExS	Clear	SE	1	Swell
272	Metre	500	914	9	9:45	4	0	S to NW	Clear	S	1	Calm
273	Metre	600	1097	9	9:45	4	0	S to NW	Clear	S	1	Calm
274	Metre	700	1280	9	9:45	4	0	S to NW	Clear	S	1	Calm
275	Metre	800	1463	9	9:45	4	0	S to NW	Clear	S	1	Calm
276	Metre	900	1646	9	9:45	4	0	S to NW	Clear	S	1	Calm
277	2Metre	1000	1829	9	9:45	4	0	S to NW	Clear	S	1	Calm
278	Metre	500	914	10	9:42	4	08	SW	Clear	NE	1	Calm
279	Metre	600	1097	10	9:42	4	08	SW	Clear	NE	1	Calm
280	Metre	700	1280	10	9:42	4	08	SW	Clear	NE	1	Calm
281	Metre	800	1463	10	9:42	4	08	SW	Clear	NE	1	Calm
282	Metre	900	1646	10	9:42	4	08	SW	Clear	NE	1	Calm
283	2Metre	1000	1829	10	9:42	4	08	SW	Clear	NE	1	Calm
284	½Metre	0	0	10	10:00	3	00	SW	Clear	NE	1	Calm
285	Metre	500	914	11	9:35	4	0	SE	Clear	ESE	2	Calm
286	Metre	600	1097	11	9:35	4	0	SE	Clear	ESE	2	Calm
287	Metre	700	1280	11	9:35	4	0	SE	Clear	ESE	2	Calm
288	Metre	800	1463	11	9:35	4	0	SE	Clear	ESE	2	Calm
289	Metre	900	1646	11	9:35	4	0	SE	Clear	ESE	2	Calm
290	2Metre	1000	1829	11	9:35	4	0	SE	Clear	ESE	2	Calm
291	Metre	500	914	12	9:33	4	07	SExS	Clear	NE	1	Calm
292	Metre	600	1097	12	9:33	4	07	SExS	Clear	NE	1	Calm
293	Metre	700	1280	12	9:33	4	07	SExS	Clear	NE	1	Calm
294	Metre	800	1463	12	9:33	4	07	SExS	Clear	NE	1	Calm
295	Metre	900	1646	12	9:33	4	07	SExS	Clear	NE	1	Calm
296	2Metre	1000	1829	12	9:33	4	07	SExS	Clear	NE	1	Calm
297	Metre	500	914	13	9:25	4	0	S	Overcast	ENE	1	Moderate
298	Metre	600	1097	13	9:25	4	0	S	Overcast	ENE	1	Moderate
299	Metre	700	1280	13	9:25	4	0	S	Overcast	ENE	1	Moderate
300	Metre	800	1463	13	9:25	4	0	S	Overcast	ENE	1	Moderate
301	Metre	900	1646	13	9:25	4	0	S	Overcast	ENE	1	Moderate
302	2Metre	1000	1829	13	9:25	4	0	S	Overcast	ENE	1	Moderate

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				July								
303	Metre	500	914	16	10:01AM	3	50	ESE to E	Squally	WSW	1	Rough
304	Metre	500	914	16	10:01	3	50	ESE to E	Squally	WSW	1	Rough
305	Metre	600	1097	16	10:01	3	50	ESE to E	Squally	WSW	1	Rough
306	Metre	700	1280	16	10:01	3	50	ESE to E	Squally	WSW	1	Rough
307	Metre	800	1463	16	10:01	3	50	ESE to E	Squally	WSW	1	Rough
308	2Metre	900	1646	16	10:01	3	50	ESE to E	Squally	WSW	1	Rough
309	Metre	500	914	22	10:00	3	55	S and W	Clear	ESE	2	Calm
310	Metre	600	1097	22	10:00	3	55	S and W	Clear	ESE	2	Calm
311	Metre	600	1097	22	10:00	3	55	S and W	Clear	ESE	2	Calm
312	Metre	700	1280	22	10:00	3	55	S and W	Clear	ESE	2	Calm
313	Metre	800	1463	22	10:00	3	55	S and W	Clear	ESE	2	Calm
314	2Metre	900	1646	22	10:00	3	55	S and W	Clear	ESE	2	Calm
315	Metre	500	914	23	9:42	4	03	SW	Clear	E	0	Swell
316	Metre	600	1097	23	9:42	4	03	SW	Clear	E	0	Swell
317	Metre	700	1280	23	9:42	4	03	SW	Clear	E	0	Swell
318	Metre	800	1463	23	9:42	4	03	SW	Clear	E	0	Swell
319	Metre	900	1646	23	9:42	4	03	SW	Clear	E	0	Swell
320	2Metre	1000	1829	23	9:42	4	03	SW	Clear	E	0	Swell
321	Metre	600	1097	24	10:10	3	0	ExS	Clear	W	2	Calm
322	Metre	700	1280	24	10:10	3	0	ExS	Clear	W	2	Calm
323	Metre	800	1463	24	10:10	3	0	ExS	Clear	W	2	Calm
324	Metre	800	1463	24	10:10	3	0	ExS	Clear	W	2	Calm
325	Metre	900	1646	24	10:10	3	0	SxE	Clear	W	2	Calm
326	2Metre	1000	1829	24	10:10	3	0	SxE	Clear	W	2	Calm
327	Metre	700	1280	27	10:00	3	25	ExS	Squally	W	3	Rough
328	Metre	800	1463	27	10:00	3	25	ExS	Squally	W	3	Rough
329	Metre	800	1463	27	10:00	3	25	ExS	Squally	W	3	Rough
330	Metre	900	1646	27	10:10	3	25	ExS	Squally	W	3	Rough
331	Metre	1000	1829	27	10:10	3	25	ExS	Squally	W	3	Rough
332	Metre	1000	1829	27	10:10	3	25	ExS	Squally	W	3	Rough
333	Metre	500	914	29	11:40	2	0	ExS	Clear	W	2	Choppy
334	Metre	500	914	29	11:40	2	0	ExS	Clear	W	2	Choppy
335	Metre	700	1280	29	11:40	2	0	ExS	Clear	W	2	Choppy
336	Metre	800	1463	29	11:40	2	0	ExS	Clear	W	2	Choppy
337	Metre	1000	1829	29	11:40	2	0	ExS	Clear	W	2	Choppy
338	Metre	1000	1829	29	11:40	2	0	ExS	Clear	W	2	Choppy
339	Metre	500	914	30	9:58	4	02	SE	Squally	W	1	Calm
340	Metre	500	914	30	9:58	4	02	SE	Squally	W	1	Calm
341	Metre	700	1280	30	9:58	4	02	SE	Squally	W	1	Calm
342	Metre	800	1463	30	9:58	4	02	SE	Squally	W	1	Calm
343	Metre	1000	1829	30	9:58	4	02	SE	Squally	W	1	Calm
344	Metre	1000	1829	30	9:58	4	02	SE	Squally	W	1	Calm
345	Metre	500	914	31	10:10	3	0	SE	Clear	SW	3	Choppy
346	Metre	500	914	31	10:10	3	0	SE	Clear	SW	3	Choppy
347	Metre	500	914	31	10:10	3	0	SE	Clear	SW	3	Choppy
348	Metre	900	1646	31	10:10	3	0	SE	Clear	SW	3	Choppy
349	Metre	1000	1829	31	10:10	3	0	SE	Clear	SW	3	Choppy
350	Metre	1000	1829	31	10:10	3	0	SE	Clear	SW	3	Choppy
				Aug.								
351	Metre	1000	1829	8	1:20PM	1	0	SE	Clear	W	3	Calm
352	Metre	1000	1829	8	1:20	1	0	SE	Clear	W	3	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth Fath-oms	Depth Metres	Date 1929	Start of Haul	Dura-tion of Haul H	M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Aug.		H	M					
353	Metre	1000	1829	8	1:20PM	1	0	SE	Clear	W	3	Calm
354	Metre	500	914	9	9:27	4	03	SE	Clear	W	3	Moderate
355	Metre	600	1097	9	9:27	4	03	SE	Clear	W	3	Moderate
356	Metre	700	1280	9	9:27	4	03	SE	Clear	W	3	Moderate
357	Metre	800	1463	9	9:27	4	03	SE	Clear	W	3	Moderate
358	Metre	900	1646	9	9:27	4	03	SE	Clear	W	3	Moderate
359	Metre	1000	1829	9	9:27	4	03	SE	Clear	W	3	Moderate
360	Metre	400	732	10	9:50	4	0	ESE	Overcast	W	3	Calm
361	Metre	500	914	10	9:50	4	0	ESE	Overcast	W	3	Calm
362	Metre	900	1646	10	9:50	4	0	ESE	Overcast	W	3	Calm
363	Metre	1000	1829	10	9:50	4	0	ESE	Overcast	W	3	Calm
364	Metre	1000	1829	10	9:50	4	0	ESE	Overcast	W	3	Calm
365	Metre	1000	1829	10	9:50	4	0	ESE	Overcast	W	3	Calm
366	Metre	400	732	14	12:08	2	02	S	Overcast	SW	3	Swell
367	Metre	400	732	14	12:08	2	02	S	Overcast	SW	3	Swell
368	Metre	700	1280	14	12:08	2	02	S	Overcast	SW	3	Swell
369	Metre	800	1463	14	12:08	2	02	S	Overcast	SW	3	Swell
370	Metre	1000	1829	14	12:08	2	02	S	Overcast	SW	3	Swell
371	Metre	1000	1829	14	12:08	2	02	S	Overcast	SW	3	Swell
372	Metre	400	732	15	9:40	4	20	SxE	Overcast	SW	3	Swell
373	Metre	500	914	15	9:40	4	20	SxE	Overcast	SW	3	Swell
374	Metre	600	1097	15	9:40	4	20	SxE	Overcast	SW	3	Swell
375	Metre	800	1463	15	9:40	4	20	SxE	Overcast	SW	3	Swell
376	Metre	1000	1829	15	9:40	4	20	SxE	Overcast	SW	3	Swell
377	Metre	1000	1829	15	9:40	4	20	SxE	Overcast	SW	3	Swell
378	Metre	500	914	16	9:27	4	03	SE	Clear	SW	2	Swell
379	Metre	600	1097	16	9:27	4	03	SE	Clear	SW	2	Swell
380	Metre	700	1280	16	9:27	4	03	SE	Clear	SW	2	Swell
381	Metre	800	1463	16	9:27	4	03	SE	Clear	SW	2	Swell
382	Metre	900	1646	16	9:27	4	03	SE	Clear	SW	2	Swell
383	Metre	1000	1829	16	9:27	4	03	SE	Clear	SW	2	Swell
384	Metre	500	914	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
385	Metre	600	1097	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
386	Metre	700	1280	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
387	Metre	800	1463	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
388	Metre	900	1646	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
389	Metre	1000	1829	17	9:30	4	0	SE to E	Overcast	SW	1	Calm
390	Metre	500	914	19	9:40	4	0	ESE	Clear	W	2	Calm
391	Metre	600	1097	19	9:40	4	0	ESE	Clear	W	2	Calm
392	Metre	700	1280	19	9:40	4	0	ESE	Clear	W	2	Calm
393	Metre	800	1463	19	9:40	4	0	ESE	Clear	W	2	Calm
394	Metre	900	1646	19	9:40	4	0	ESE	Clear	W	2	Calm
395	Metre	1000	1829	19	9:40	4	0	ESE	Clear	W	2	Calm
396	Metre	600	1097	31	10:00	4	0	ESE	Clear	SW	2	Rough
397	Metre	700	1280	31	10:00	4	0	ESE	Clear	SW	2	Rough
398	Metre	800	1463	31	10:00	4	0	ESE	Clear	SW	2	Rough
399	Metre	900	1646	31	10:00	4	0	ESE	Clear	SW	2	Rough
400	Metre	1000	1829	31	10:00	4	0	ESE	Clear	SW	2	Rough
401	Metre	1100	2011	31	10:00	4	0	ESE	Clear	SW	2	Rough
402	Metre	2	7	31	10:00	4	0	ESE	Clear	SW	2	Rough

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				Sept.								
403	Metre	500	914	2	9:45AM	4	10	SW	Overcast	NExN	3	Calm
404	Metre	600	1097	2	9:45	4	10	SW	Overcast	NExN	3	Calm
405	Metre	700	1280	2	9:45	4	10	SW	Overcast	NExN	3	Calm
406	Metre	800	1463	2	9:45	4	10	SW	Overcast	NExN	3	Calm
407	Metre	900	1646	2	9:45	4	10	SW	Overcast	NExN	3	Calm
408	Metre	1000	1829	2	9:45	4	10	SW	Overcast	NExN	3	Calm
409	Metre	500	914	3	9:30	4	0	SW	Misty	NNW	4	Rough
410	Metre	600	1097	3	9:30	4	0	SW	Misty	NNW	4	Rough
411	Metre	700	1280	3	9:30	4	0	SW	Misty	NNW	4	Rough
412	Metre	800	1463	3	9:30	4	0	SW	Misty	NNW	4	Rough
413	Metre	900	1646	3	9:30	4	0	SW	Misty	NNW	4	Rough
414	Metre	1000	1829	3	9:30	4	0	SW	Misty	NNW	4	Rough
415	Metre	2	7	3	9:05	4	25	SW	Misty	NNW	4	Rough
416	Metre	500	914	4	9:32	4	03	SW	Misty	N	3	Choppy
417	Metre	600	1097	4	9:32	4	03	SW	Misty	N	3	Choppy
418	Metre	700	1280	4	9:32	4	03	SW	Misty	N	3	Choppy
419	Metre	800	1463	4	9:32	4	03	SW	Misty	N	3	Choppy
420	Metre	900	1646	4	9:32	4	03	SW	Misty	N	3	Choppy
421	Metre	1000	1829	4	9:32	4	03	SW	Misty	N	3	Choppy
422	Metre	2	7	4	8:40	4	50	SW	Misty	N	3	Choppy
423	Metre	500	914	5	9:45	4	0	SW	Clear	E	1	Calm
424	Metre	600	1097	5	9:45	4	0	SW	Clear	E	1	Calm
425	Metre	700	1280	5	9:45	4	0	SW	Clear	E	1	Calm
426	Metre	800	1463	5	9:45	4	0	SW	Clear	E	1	Calm
427	Metre	900	1646	5	9:45	4	0	SW	Clear	E	1	Calm
428	2Metre	1000	1829	5	9:45	4	0	SW	Clear	E	1	Calm
429	Metre	2	7	5	9:20	4	20		Clear	E	1	Calm
430	Metre	500	914	6	9:50	4	0	S	Misty	ESE	1	Calm
431	Metre	600	1097	6	9:50	4	0	S	Misty	ESE	1	Calm
432	Metre	700	1280	6	9:50	4	0	S	Misty	ESE	1	Calm
433	Metre	800	1463	6	9:50	4	0	S	Misty	ESE	1	Calm
434	Metre	900	1646	6	9:50	4	0	S	Misty	ESE	1	Calm
435	2Metre	1000	1829	6	9:50	4	0	S	Misty	ESE	1	Calm
436	Misty	2	7	6	9:25	4	20	S	Misty	ESE	1	Calm
437	Metre	500	914	7	9:50	4	0	SW	Overcast	SE	3	Choppy
438	Metre	600	1097	7	9:50	4	0	SW	Overcast	SE	3	Choppy
439	Metre	700	1280	7	9:50	4	0	SW	Overcast	SE	3	Choppy
440	Metre	900	1646	7	9:50	4	0	SW	Overcast	SE	3	Choppy
441	Metre	1000	1829	7	9:50	4	0	SW	Overcast	SE	3	Choppy
442	2Metre	1000	1829	7	9:50	4	0	SW	Overcast	SE	3	Choppy
443	Metre	2	7	7	8:45	5	05	SW	Overcast	SE	3	Choppy
444	Metre	500	914	9	11:35	2	25	SW	Clear	SE	2	Moderate
445	Metre	600	1097	9	11:35	2	25	SW	Clear	SE	2	Moderate
446	Metre	700	1280	9	11:35	2	25	SW	Clear	SE	2	Moderate
447	Metre	800	1463	9	11:35	2	25	SW	Clear	SE	2	Moderate
448	Metre	900	1646	9	11:35	2	25	SW	Clear	SE	2	Moderate
449	2Metre	1000	1829	9	11:35	2	25	SW	Clear	SE	2	Moderate
450	Metre	2	7	9	11:15	2	45	SW	Clear	SE	2	Moderate
451	Metre	500	914	10	9:35	4	0	SW	Clear	SE	1	Calm
452	Metre	500	914	10	9:35	4	0	SW	Clear	SE	1	Calm
453	Metre	600	1097	10	9:35	4	0	SW	Clear	SE	1	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				Sept.		H	M					
454	Metre	900	1646	10	9:35AM	4	0	SW	Clear	SE	1	Calm
455	Metre	1000	1829	10	9:35	4	0	SW	Clear	SE	1	Calm
456	2Metre	1000	1829	10	9:35	4	0	SW	Clear	SE	1	Calm
457	Metre	2	7	10	9:20	4	05	SW	Clear	SE	1	Calm
458	Metre	300	549	11	9:30	4	0	SW	Clear	SE	1	Calm
459	Metre	400	732	11	9:30	4	0	SW	Clear	SE	1	Calm
460	Metre	700	1280	11	9:30	4	0	SW	Clear	SE	1	Calm
461	Metre	800	1463	11	9:30	4	0	SW	Clear	SE	1	Calm
462	Metre	900	1646	11	9:30	4	0	SW	Clear	SE	1	Calm
463	Metre	1000	1829	11	9:30	4	0	SW	Clear	SE	1	Calm
464	Metre	2	7	11	9:20	4	10	SW	Clear	SE	1	Calm
465	Metre	800	1463	12	9:00	4	0	SW	Clear	SE	1	Calm
466	Metre	900	1646	12	9:00	4	0	SW	Clear	SE	1	Calm
467	Metre	900	1646	12	9:00	4	0	SW	Clear	SE	1	Calm
468	Metre	1000	1829	12	9:00	4	0	SW	Clear	SE	1	Calm
469	Metre	1000	1829	12	9:00	4	0	SW	Clear	SE	1	Calm
470	2Metre	1000	1829	12	9:00	4	0	SW	Clear	SE	1	Calm
471	Metre	2	7	12	8:22	4	38		Clear	SE	1	Calm
472	Metre	100	183	13	9:30	4	0	SW	Clear	SE	3	Choppy
473	Metre	200	366	13	9:30	4	0	SW	Clear	SE	3	Choppy
474	Metre	700	1280	13	9:30	4	0	SW	Clear	SE	3	Choppy
475	Metre	800	1463	13	9:30	4	0	SW	Clear	SE	3	Choppy
476	Metre	900	1646	13	9:30	4	0	SW	Clear	SE	3	Choppy
477	Metre	2	7	13	9:30	4	0	SW	Clear	SE	3	Choppy
478	Metre	500	914	20	9:40	4	0	SxW	Overcast	S	1	Swell
479	Metre	600	1097	20	9:40	4	0	SxW	Overcast	S	1	Swell
480	Metre	700	1280	20	9:40	4	0	SxW	Overcast	S	1	Swell
481	Metre	800	1463	20	9:40	4	0	SxW	Overcast	S	1	Swell
482	Metre	900	1646	20	9:40	4	0	SxW	Overcast	S	1	Swell
483	Metre	1000	1829	20	9:40	4	0	SxW	Overcast	S	1	Swell
484	Metre	500	914	21	9:44	4	0	S	Clear	SW	3	Moderate
485	Metre	600	1097	21	9:44	4	0	S	Clear	SW	3	Moderate
486	Metre	700	1280	21	9:44	4	0	S	Clear	SW	3	Moderate
487	Metre	800	1463	21	9:44	4	0	S	Clear	SW	3	Moderate
488	Metre	900	1646	21	9:44	4	0	S	Clear	SW	3	Moderate
489	Metre	1000	1829	21	9:44	4	0	S	Clear	SW	3	Moderate
490	Metre	2	7	21	9:44	4	0	S	Clear	SW	3	Moderate
491	½Metre	2	7	22	2:00PM		35	S and N	Clear	SW	1	Calm
492	Metre	500	914	23	10:05AM	2	0	S to SW	Clear	SE	1	Swell
493	Metre	600	1097	23	10:05	2	0	S to SW	Clear	SE	1	Swell
494	Metre	700	1280	23	10:05	2	0	S to SW	Clear	SE	1	Swell
495	Metre	800	1463	23	10:05	2	0	S to SW	Clear	SE	1	Swell
496	Metre	900	1646	23	10:05	2	0	S to SW	Clear	SE	1	Swell
497	Metre	1000	1829	23	10:05	2	0	S to SW	Clear	SE	1	Swell
498	Metre	2	7	23	10:05	2	0	S to SW	Clear	SE	1	Swell
499	Metre	800	1463	24	10:35	3	0	E	Squally	W	3	Rough
500	Metre	900	1646	24	10:35	3	0	E	Squally	W	3	Rough
501	Metre	900	1646	24	10:35	3	0	E	Squally	W	3	Rough
502	Metre	900	1646	24	10:35	3	0	E	Squally	W	3	Rough
503	Metre	2	7	24	10:35	3	0	E	Squally	W	3	Rough
504	Metre	500	914	25	10:10	3	20	SE	Overcast	SW	3	Rough

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1929	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				Sept.		H	M					
505	Metre	600	1097	25	10:10AM	3	20	SE	Overcast	SW	3	Rough
506	Metre	700	1280	25	10:10	3	20	SE	Overcast	SW	3	Rough
507	Metre	700	1280	25	10:10	3	20	SE	Overcast	SW	3	Rough
508	Metre	800	1463	25	10:10	3	20	SE	Overcast	SW	3	Rough
509	Metre	800	1463	25	10:10	3	20	SE	Overcast	SW	3	Rough
510	Metre	2	7	25	10:10	3	20	SE	Overcast	SW	3	Rough
511	Metre	700	1280	27	10:45	3	0	SE	Squally	NW	1	Swell
512	Metre	700	1280	27	10:45	3	0	SE	Squally	NW	1	Swell
513	Metre	700	1280	27	10:45	3	0	SE	Squally	NW	1	Swell
514	Metre	800	1463	27	10·45	3	0	SE	Squally	NW	1	Swell
515	Metre	800	1463	27	10:45	3	0	SE	Squally	NW	1	Swell
516	Metre	1000	1829	27	10:45	3	0	SE	Squally	NW	1	Swell
517	Metre	2	7	27	10·45	3	0	SE	Squally	NW	1	Swell
518	Peters	1000	1829	28	10·26		24	NE	Squally	NE	3	Swell
519	Metre	0–100	183	30	9·06				Clear	N	1	Calm
520	Metre	0–200	366	30					Clear	N	1	Calm
521	Metre	0–300	549	30					Clear	N	1	Calm
522	Metre	0–400	732	30					Clear	N	1	Calm
523	Metre	0–500	914	30					Clear	N	1	Calm
524	Metre	0–600	1097	30					Clear	N	1	Calm
525	Metre	0–700	1280	30					Clear	N	1	Calm
526	Metre	0–800	1463	30					Clear	N	1	Calm
527	Metre	0–900	1646	30					Clear	N	1	Calm
528	Metre	0–1000	1829	30					Clear	N	1	Calm
				1930								
				Apr								
529	Metre	0	0	18	7.40PM		20	SE	Clear	W	1	Calm
530	Metre	0	0	19	7·40		35	Circle	No moon	W	1	Calm
531	Metre	0	0	22	7:40		30	Circle	No moon	SW	3	Choppy
532	Metre	0	0	25	7.40		40	Circle	No moon	NE	2	Calm
533	Metre	0	0	26	7:32		40	NW	No moon	E	1	Calm
534	Metre	0	0	29	8:00		20	Circle	Starlight	ENE	4	Choppy
535	Metre	0	0	30	5·00		20	Circle	Clear	SE	2	Choppy
				May								
536	Metre	0	0	2	7.40		30	Circle	Moonlight	SE	4	Choppy
537	Metre	0	0	4	7:45		30	Circle	Moonlight	SW	4	Choppy
538	Metre	500	914	6	9·16AM	3	15	ESE to E	Clear	NE	3	Swell
539	Metre	600	1097	6	9·16	3	15	ESE to E	Clear	NE	3	Swell
540	Metre	700	1280	6	9:16	3	15	ESE to E	Clear	NE	3	Swell
541	Metre	800	1463	6	9:16	3	15	ESE to E	Clear	NE	3	Swell
542	Metre	900	1646	6	9:16	3	15	ESE to E	Clear	NE	3	Swell
543	Metre	1000	1829	6	9:16	3	15	ESE to E	Clear	NE	3	Swell
544	Metre	500	914	7	9:25	3	05	SE to E	Clear	NxE	1	Calm
545	Metre	600	1097	7	9:25	3	05	SE to E	Clear	NxE	1	Calm
546	Metre	1000	1829	7	9:25	3	05	SE to E	Clear	NxE	1	Calm
547	Metre	1100	2011	7	9:25	3	05	SE to E	Clear	NxE	1	Calm
548	Metre	1200	2195	7	9:25	3	05	SE to E	Clear	NxE	1	Calm
549	Metre	0	0	7	9:22	3	00	SE to E	Clear	NxE	1	Calm
550	Metre	0	0	7	10.00PM	2	00	Circle	Moonlight	E	0	Calm
551	Metre	500	914	9	9:35AM	4	00	SE	Clear	SE	1	Calm
552	Metre	600	1097	9	9:35	4	00	SE	Clear	SE	1	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1930	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				May								
553	Metre	700	1280	9	9:35AM	4	00	SE	Clear	SE	1	Calm
554	Metre	800	1463	9	9:35	4	00	SE	Clear	SE	1	Calm
555	Metre	900	1646	9	9:35	4	00	SE	Clear	SE	1	Calm
556	Metre	1000	1829	9	9:35	4	00	SE	Clear	SE	1	Calm
557	Metre	0	0	9	9:20	4	10	SE	Clear	SE	1	Calm
558	Metre	100	183	10	9:05	3	10	ESE	Clear	NW	3	Choppy
559	Metre	200	366	10	9:05	3	10	ESE	Clear	NW	3	Choppy
560	Metre	300	549	10	9:05	3	10	ESE	Clear	NW	3	Choppy
561	Metre	400	732	10	9:05	3	10	ESE	Clear	NW	3	Choppy
562	Metre	500	914	10	9:05	3	10	ESE	Clear	NW	3	Choppy
563	Metre	600	1097	10	9:05	3	10	ESE	Clear	NW	3	Choppy
564	Metre	0	0	10	9:05	3	10	ESE	Clear	NW	3	Choppy
565	Metre	500	914	12	9:11	3	49	SExE	Clear	NW	2	Rough
566	Metre	600	1097	12	9:11	3	49	SExE	Clear	NW	2	Rough
567	Metre	700	1280	12	9:11	3	49	SExE	Clear	NW	2	Rough
568	Metre	800	1463	12	9:11	3	49	SExE	Clear	NW	2	Rough
569	Metre	900	1646	12	9:11	3	49	SExE	Clear	NW	2	Rough
570	Metre	1000	1829	12	9:11	3	49	SExE	Clear	NW	2	Rough
571	Metre	0	0	12	8:45	4	05	SExE	Clear	NW	1	Calm
572	Metre	300	549	14	9:07	4	03	SE	Clear	NW	1	Calm
573	Metre	400	732	14	9:07	4	03	SE	Clear	NW	1	Calm
574	Metre	500	914	14	9:07	4	03	SE	Clear	NW	1	Calm
575	Metre	600	1097	14	9:07	4	03	SE	Clear	NW	1	Calm
576	Metre	700	1280	14	9:07	4	03	SE	Clear	NW	1	Calm
577	Metre	800	1463	14	9:07	4	03	SE	Clear	NW	1	Calm
578	Metre	0	0	14	9:15	3	45	SE	Clear	NW	1	Calm
579	Metre	300	549	15	9:12	3	15	SW	Overcast	S	4	Rough
580	Metre	400	732	15	9:12	3	15	SW	Overcast	S	4	Rough
581	Metre	500	914	15	9:12	3	15	SW	Overcast	S	4	Rough
582	Metre	600	1097	15	9:12	3	15	SW	Overcast	S	4	Rough
583	Metre	700	1280	15	9:12	3	15	SW	Overcast	S	4	Rough
584	Metre	800	1463	15	9:12	3	15	SW	Overcast	S	4	Rough
585	Metre	0	0	15	9:05	3	15	SW	Overcast	S	4	Rough
586	Metre	400	732	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
587	Metre	500	914	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
588	Metre	600	1097	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
589	Metre	700	1280	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
590	Metre	800	1463	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
591	Metre	900	1646	17	9:18	4	00	ExS-ExN	Clear	SW	2	Swell
592	Metre	0	0	17	9:08	3	07	ExS-ExN	Clear	SW	2	Swell
593	Metre	0	0	17	8:00PM		35	Circle	No moon	W	1	Calm
594	Metre	400	732	19	9:10AM	4	00	SE	Misty	W	1	Choppy
595	Metre	500	914	19	9:10	4	00	SE	Misty	W	1	Choppy
596	Metre	600	1097	19	9:10	4	00	SE	Misty	W	1	Choppy
597	Metre	700	1280	19	9:10	4	00	SE	Misty	W	1	Choppy
598	Metre	800	1463	19	9:10	4	00	SE	Misty	W	1	Choppy
599	Metre	900	1646	19	9:10	4	00	SE	Misty	W	1	Choppy
600	Metre	0	0	19	9:00	3	50	SE	Misty	W	1	Choppy
601	Metre	0	0	19			40		Overcast	W	1	Choppy
602	Metre	200	366	20	9:12	4	00	SW	Overcast	W	3	Choppy
603	Metre	300	549	20	9:12	4	00	SW	Overcast	W	3	Choppy

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1930	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				May		H	M					
604	Metre	400	732	20	9:12AM	4	00	SW	Overcast	W	3	Choppy
605	Metre	500	914	20	9:12	4	00	SW	Overcast	W	3	Choppy
606	Metre	500	914	20	9:12	4	00	SW	Overcast	W	3	Choppy
607	Metre	500	914	20	9:12	4	00	SW	Overcast	W	3	Choppy
608	Metre	0	0	20	9:10	4	00	SW	Overcast	W	3	Choppy
609	Metre	300	549	21	9:30	2	20	ExN	Squally	S	3	Choppy
610	Metre	400	732	21	9:30	2	20	ExN	Squally	S	3	Choppy
611	Metre	500	914	21	9:30	2	20	ExN	Squally	S	3	Choppy
612	Metre	600	1097	21	9:30	2	20	ExN	Squally	S	3	Choppy
613	Metre	600	1097	21	9:30	2	20	ExN	Squally	S	3	Choppy
614	Metre	600	1097	21	9:30	2	20	ExN	Squally	S	3	Choppy
615	Metre	0	0	21	9:30	1	50	ExN	Squally	S	3	Choppy
616	Metre	300	549	22	8:52	4	08	ExS	Clear	N	3	Swell
617	Metre	400	732	22	9:52	4	08	ExS	Clear	N	3	Swell
618	Metre	500	914	22	9:52	4	08	ExS	Clear	N	3	Swell
619	Metre	500	914	22	9:52	4	08	ExS	Clear	N	3	Swell
620	Metre	600	1097	22	8:52	4	08	ExS	Clear	N	3	Swell
621	Metre	600	1097	22	9:52	4	08	ExS	Clear	N	3	Swell
622	Metre	0	0	22	8:51	4	09	ExS	Clear	N	3	Swell
623	Metre	300	549	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
624	Metre	400	732	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
625	Metre	500	914	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
626	Metre	500	914	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
627	Metre	600	1097	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
628	Metre	600	1097	23	9:11	4	00	SSE-ENE	Clear	N	3	Swell
629	Metre	0	0	23	9:00	4	10	SSE-ENE	Clear	N	3	Swell
630	Metre	300	549	26	8:56	4	09	SWxS	Misty	S	2	Swell
631	Metre	400	732	26	8:56	4	09	SWxS	Misty	S	2	Swell
632	Metre	500	914	26	8:56	4	09	SWxS	Misty	S	2	Swell
633	Metre	500	914	26	8:56	4	09	SWxS	Misty	S	2	Swell
634	Metre	600	1097	26	8:56	4	09	SWxS	Misty	S	2	Swell
635	Metre	600	1097	26	8:56	4	09	SWxS	Misty	S	2	Swell
636	Metre	0	0	26	8:50	4	10	SWxS	Misty	S	2	Swell
637	Metre	500	914	28	9:01	3	59	SExE	Overcast	WNW	4	Rough
638	Metre	600	1097	28	9:01	3	59	SExE	Overcast	WNW	4	Rough
639	Metre	700	1280	28	9:01	3	59	SExE	Overcast	WNW	4	Rough
640	Metre	800	1463	28	9:01	3	50	SExE	Overcast	WNW	4	Rough
641	Metre	900	1646	28	9:01	3	50	SExE	Overcast	WNW	4	Rough
642	Metre	1000	1829	28	9:01	3	50	SExE	Overcast	WNW	4	Rough
643	Metre	0	0	28	8:45	4	05	SExE	Overcast	WNW	4	Rough
644	Metre	600	1097	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
645	Metre	600	1097	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
646	Metre	600	1097	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
647	Metre	700	1280	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
648	Metre	800	1463	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
649	Metre	900	1646	29	9:01	3	54	SSW	Clear	WxN	2	Moderate
650	Metre	0	0	29	8:40	3	25	SSW	Clear	WxN	2	Moderate
651	Metre	500	914	30	11:10	2	20	SSW	Overcast	S	3	Choppy
652	Metre	500	914	30	11:10	2	20	SSW	Overcast	S	3	Choppy
653	Metre	500	914	30	11:10	2	20	SSW	Overcast	S	3	Choppy
654	Metre	0	0	30	11:15	2	10	SSW	Overcast	S	3	Choppy

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1930	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				July		H	M					
756	Metre	1000	1829	1	9:00AM	4	45	SW	Clear	SW	1	Calm
757	Metre	1000	1829	1	9:00	4	45	SW	Clear	SW	1	Calm
758	Metre	500	914	2	9:42	4	20	WxS	Overcast	S	3	Swell
759	Metre	700	1280	2	9:42	4	20	WxS	Overcast	S	3	Swell
760	Metre	800	1463	2	9:42	4	20	WxS	Overcast	S	3	Swell
761	Metre	900	1646	2	9:42	4	20	WxS	Overcast	S	3	Swell
762	Metre	1000	1829	2	9:42	4	20	WxS	Overcast	S	3	Swell
763	Metre	300	549	3	11:15	3	00	E	Squally	S	2	Choppy
764	Metre	400	732	3	11:15	3	00	E	Squally	S	2	Choppy
765	Metre	500	914	3	11:15	3	00	E	Squally	S	2	Choppy
766	Metre	500	914	3	11:15	3	00	E	Squally	S	2	Choppy
767	Metre	800	1463	3	11:15	3	00	E	Squally	S	2	Choppy
768	Metre	800	1463	3	11:15	3	00	E	Squally	S	2	Choppy
769	Metre	0	0	3	9:00PM		40	E	Overcast	SW	2	Choppy
770	Metre	700	1280	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
771	Metre	900	1646	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
772	Metre	900	1646	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
773	Metre	1000	1829	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
774	Metre	1000	1829	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
775	Metre	1000	1829	4	9:40	4	20	SW	Cloudy	SW	2	Choppy
776	Metre	500	914	5	9:04	5	21	S	Squally	SW	3	Choppy
777	Metre	600	1097	5	9:04	5	21	S	Squally	SW	3	Choppy
778	Metre	700	1280	5	9:04	5	21	S	Squally	SW	3	Choppy
779	Metre	800	1463	5	9:04	5	21	S	Squally	SW	3	Choppy
780	Metre	900	1646	5	9:04	5	21	S	Squally	SW	3	Choppy
781	Metre	1000	1829	5	9:04	5	21	S	Squally	SW	3	Choppy
782	Metre	0	0	5	10:00PM	2	00	Circle	Moonlight	SW	1	Choppy
783	#20D	0	0	5	10:00	2	00	Circle	Moonlight	SW	1	Choppy
784	Metre	500	914	7	9:30AM	4	30	E	Squally	SW	1	Choppy
785	Metre	600	1097	7	9:30	4	30	E	Squally	SW	1	Choppy
786	Metre	700	1280	7	9:30	4	30	E	Squally	SW	1	Choppy
787	Metre	800	1463	7	9:30	4	30	E	Squally	SW	1	Choppy
788	Metre	900	1646	7	9:30	4	30	E	Squally	SW	1	Choppy
789	Metre	1000	1829	7	9:30	4	30	E	Squally	SW	1	Choppy
790	Metre	0	0	8	8:30PM		20	ESE	Moonlight	SW	2	Choppy
791	Metre	500	914	9	9:34AM	4	26	SW	Overcast	SW	2	Swell
792	Metre	600	1097	9	9:34	4	26	SW	Overcast	SW	2	Swell
793	Metre	700	1280	9	9:34	4	26	SW	Overcast	SW	2	Swell
794	Metre	800	1463	9	9:34	4	26	SW	Overcast	SW	2	Swell
795	Metre	900	1646	9	9:34	4	26	SW	Overcast	SW	2	Swell
796	Metre	1000	1829	9	9:34	4	26	SW	Overcast	SW	2	Swell
797	Metre	500	914	15	9:37	4	23	SSW	Clear	SW	3	Moderate
798	Metre	600	1097	15	9:37	4	23	SSW	Clear	SW	3	Moderate
799	Metre	700	1280	15	9:37	4	23	SSW	Clear	SW	3	Moderate
800	Metre	800	1463	15	9:37	4	23	SSW	Clear	SW	3	Moderate
801	Metre	900	1646	15	9:37	4	23	SSW	Clear	SW	3	Moderate
802	Metre	1000	1829	15	9:37	4	23	SSW	Clear	SW	3	Moderate
803	Metre	0	0	15	8:00PM		40	E	No moon	SW	2	Calm
804	Metre	500	914	16	9:22AM	4	38	SW	Overcast	SW	1	Moderate
805	Metre	600	1097	16	9:22	4	38	SW	Overcast	SW	1	Moderate
806	Metre	700	1280	16	9:22	4	38	SW	Overcast	SW	1	Moderate

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1930	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				July		H	M					
807	Metre	800	1463	16	9:22AM	4	38	SW	Overcast	SW	1	Moderate
808	Metre	900	1646	16	9:22	4	38	SW	Overcast	SW	1	Moderate
809	Metre	1000	1829	16	9:22	4	38	SW	Overcast	SW	1	Moderate
				Aug.								
810	Metre	600	1097	28	9:16	4	14	E	Clear	S	1	Calm
811	Metre	600	1097	28	9:16	4	14	E	Clear	S	1	Calm
812	Metre	600	1097	28	9:16	4	14	E	Clear	S	1	Calm
813	Metre	700	1280	28	9:16	4	14	E	Clear	S	1	Calm
814	Metre	800	1463	28	9:16	4	14	E	Clear	S	1	Calm
815	Metre	900	1646	28	9:16	4	14	E	Clear	S	1	Calm
816	Metre	600	1097	29	9:23	3	42	SW	Squally	SW	3	Rough
817	Metre	600	1097	29	9:23	3	42	SW	Squally	SW	3	Rough
818	Metre	600	1097	29	9:23	3	42	SW	Squally	SW	3	Rough
819	Metre	800	1463	29	9:23	3	42	SW	Squally	SW	3	Rough
820	Metre	900	1646	29	9:23	3	42	SW	Squally	SW	3	Rough
821	Metre	0	0	29	8:20PM		40	S	Moonlight	SW	2	Swell
				Sept.								
822	Metre	600	1097	1	9:35	4	25	E	Clear	E	2	Moderate
823	Metre	700	1280	1	9:35	4	25	E	Clear	E	2	Moderate
824	Metre	800	1463	1	9:35	4	25	E	Clear	E	2	Moderate
825	Metre	800	1463	1	9:35	4	25	E	Clear	E	2	Moderate
826	Metre	900	1646	1	9:35	4	25	E	Clear	E	2	Moderate
827	Metre	1000	1829	1	9:35	4	25	E	Clear	E	2	Moderate
828	Metre	500	914	2	9:27	4	03	NxE	Overcast	E	3	Moderate
829	Metre	600	1097	2	9:27	4	03	NxE	Overcast	E	3	Moderate
830	Metre	700	1280	2	9:27AM	4	03	NxE	Overcast	E	3	Moderate
831	Metre	900	1646	2	9:27	4	03	NxE	Overcast	E	3	Moderate
832	Metre	900	1646	2	9:27	4	03	NxE	Overcast	E	3	Moderate
833	Metre	1000	1829	2	9:27	4	03	NxE	Overcast	E	3	Moderate
834	Metre	400	732	3	9:01	4	44	ExN	Clear	N	1	Calm
835	Metre	500	914	3	9:01	4	44	ExN	Clear	N	1	Calm
836	Metre	500	914	3	9:01	4	44	ExN	Clear	N	1	Calm
837	Metre	600	1097	3	9:01	4	44	ExN	Clear	N	1	Calm
838	Metre	600	1097	3	9:01	4	44	ExN	Clear	N	1	Calm
839	Metre	700	1280	3	9:01	4	44	ExN	Clear	N	1	Calm
840	Metre	0	0	3	8:10PM		40	NW	Clear	W	1	Calm
841	Metre	500	914	4	9:34AM	3	56	SW	Overcast	W	1	Calm
842	Metre	600	1097	4	9:34	3	56	SW	Overcast	W	1	Calm
843	Metre	700	1280	4	9:34	3	56	SW	Overcast	W	1	Calm
844	Metre	800	1463	4	9:34	3	56	SW	Overcast	W	1	Calm
845	Metre	900	1646	4	9:34	3	56	SW	Overcast	W	1	Calm
846	Metre	1000	1829	4	9:34	3	56	SW	Overcast	W	1	Calm
847	Metre	500	914	5	9:13	4	22	NE	Squally	NW	3	Calm
848	Metre	600	1097	5	9:13	4	22	NE	Squally	NW	3	Calm
849	Metre	700	1280	5	9:13	4	22	NE	Squally	NW	3	Calm
850	Metre	800	1463	5	9:13	4	22	NE	Squally	NW	3	Calm
851	Metre	900	1646	5	9:13	4	22	NE	Squally	NW	3	Calm
852	Metre	1000	1829	5	9 13	4	22	NE	Squally	NW	3	Calm
853	Metre	500	914	6	9:07	4	23	ESE	Clear	NW	1	Calm
854	Metre	600	1097	6	9:07	4	23	ESE	Clear	NW	1	Calm
855	Metre	700	1280	6	9:07	4	23	ESE	Clear	NW	1	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1930	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				Sept.		H	M					
856	Metre	800	1463	6	9:07AM	4	23	ESE	Clear	NW	1	Calm
857	Metre	900	1646	6	9:07	4	23	ESE	Clear	NW	1	Calm
858	Metre	1000	1829	6	9:07	4	23	ESE	Clear	NW	1	Calm
859	Metre	500	914	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
860	Metre	600	1097	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
861	Metre	700	1280	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
862	Metre	800	1463	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
863	Metre	900	1646	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
864	Metre	1000	1829	8	9:29	4	01	SWxW	Overcast	SW	3	Swell
865	Metre	600	1097	10	9:38	2	52	SW	Overcast	SW	3	Swell
866	Metre	700	1280	10	9:38	2	52	SW	Overcast	SW	3	Swell
867	Metre	800	1463	10	9:38	2	52	SW	Overcast	SW	3	Swell
868	Metre	900	1646	10	9:38	2	52	SW	Overcast	SW	3	Swell
869	Metre	1000	1829	10	9:38	2	52	SW	Overcast	SW	3	Swell
870	Metre	100	183	11	10:03	2	27	E-NE-E	Squally	NE	1	Calm
871	Metre	200	366	11	10:03	2	27	E-NE-E	Squally	NE	1	Calm
872	Metre	300	549	11	10:03	2	27	E-NE-E	Squally	NE	1	Calm
873	Metre	400	732	11	10:03	2	27	E-NE-E	Squally	NE	1	Calm
874	Metre	500	914	11	10 03	2	27	E-NE-E	Squally	NE	1	Calm
875	Metre	600	1097	11	10:03	2	27	E-NE-E	Squally	NE	1	Calm
876	Metre	100	183	12	11:22	3	00	ExN	Squally	N	1	Calm
877	Metre	200	366	12	11:22	3	00	ExN	Squally	N	1	Calm
878	Metre	300	549	12	11:22	3	00	ExN	Squally	N	1	Calm
879	Metre	400	732	12	11·22	3	00	ExN	Squally	N	1	Calm
880	Metre	500	914	12	11:22	3	00	ExN	Squally	N	1	Calm
881	Metre	600	1097	12	11:22	3	00	ExN	Squally	N	1	Calm
882	Metre	700	1280	13	9:33	4	27	SWxW	Overcast	W	3	Swell
883	Metre	700	1280	13	9:33	4	27	SWxW	Overcast	W	3	Swell
884	Metre	800	1463	13	9:33	4	27	SWxW	Overcast	W	3	Swell
885	Metre	800	1463	13	9:33	4	27	SWxW	Overcast	W	3	Swell
886	Metre	900	1646	13	9:33	4	27	SWxW	Overcast	W	3	Swell
887	Metre	900	1646	13	9.33	4	27	SWxW	Overcast	W	3	Swell
888	Metre	400	732	15	9:20	4	00	SWxW	Squally	NW	3	Rough
889	Metre	500	914	15	9:20	4	00	SWxW	Squally	NW	3	Rough
890	Metre	600	1097	15	9:20	4	00	SWxW	Squally	NW	3	Rough
891	Metre	700	1280	15	9:20	4	00	SWxW	Squally	NW	3	Rough
892	Metre	800	1463	15	9:20	4	00	SWxW	Squally	NW	3	Rough
893	Metre	900	1646	15	9:20	4	00	SWxW	Squally	NW	3	Rough
894	Metre	500	914	16	9:29	4	26	SSE	Clear	NW	3	Calm
895	Metre	600	1097	16	9:29	4	26	SSE	Clear	NW	3	Calm
896	Metre	700	1280	16	9:29	4	26	SSE	Clear	NW	3	Calm
897	Metre	800	1463	16	9:29	4	26	SSE	Clear	NW	3	Calm
898	Metre	900	1646	16	9:29	4	26	SSE	Clear	NW	3	Calm
899	Metre	1000	1829	16	9:29	4	26	SSE	Clear	NW	3	Calm
900	Metre	0	0	16	8:00PM	1	00	S	Clear	N	2	Calm
901	Metre	600	1097	17	9:10AM	4	05	SWxW	Clear	E	2	Calm
902	Metre	700	1280	17	9:10	4	05	SWxW	Clear	E	2	Calm
903	Metre	800	1463	17	9:10	4	05	SWxW	Clear	E	2	Calm
904	Metre	900	1646	17	9:10	4	05	SWxW	Clear	E	2	Calm
905	Metre	900	1646	17	9:10	4	05	SWxW	Clear	E	2	Calm
906	Metre	800	1463	17	9:10	4	05	SWxW	Clear	E	2	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No	Type of Net	Depth Fathoms	Depth Metres	Date 1930	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Sept.		H	M					
907	Metre	0-100	0–183	18	1:40PM		10		Clear	NE	2	Calm
908	Metre	0 200	0–366	18	1:57		15		Clear	NE	2	Calm
909	Metre	0 300	0–549	18	2:23		20		Clear	NE	2	Calm
910	Metre	0 400	0–732	18	2.51		28		Clear	NE	2	Calm
911	Metre	0 500	0–914	18	8:21AM		41		Clear	NE	2	Calm
912	Metre	0 600	0–1097	18	9:17		48		Clear	NE	2	Calm
913	Metre	0-800	0–1463	18	10.20	1	00		Clear	NE	2	Calm
914	Metre	0-1000	0–1829	18	11 37	1	36		Clear	NE	2	Calm
915	Metre	500	914	19	9:15	4	30	SE	Clear	NW	1	Calm
916	Metre	500	914	19	9·15	4	30	SE	Clear	NW	1	Calm
917	Metre	600	1097	19	9·15	4	30	SE	Clear	NW	1	Calm
918	Metre	700	1280	19	9·15	4	30	SE	Clear	NW	1	Calm
919	Metre	700	1280	19	9·15	4	30	SE	Clear	NW	1	Calm
920	Metre	0	0	19	9·15	4	30	SE	Clear	NW	1	Calm
921	Metre	500	914	20	9:20	3	55	SW	Squally	NW	2	Moderate
922	Metre	600	1097	20	9.20	3	55	SW	Squally	NW	2	Moderate
923	Metre	600	1097	20	9 20	3	55	SW	Squally	NW	2	Moderate
924	Metre	800	1463	20	9:20	3	55	SW	Squally	NW	2	Moderate
925	Metre	900	1646	20	9 20	3	55	SW	Squally	NW	2	Moderate
926	Metre	900	1646	20	9 20	3	55	SW	Squally	NW	2	Moderate
927	Metre	500	914	22	10.33	3	27	NExN	Clear	NW	2	Choppy
928	Metre	500	914	22	10 33	3	27	NExN	Clear	NW	2	Choppy
929	Metre	700	1280	22	10:33	3	27	NExN	Clear	NW	2	Choppy
930	Metre	700	1280	22	10 33	3	27	NExN	Clear	NW	2	Choppy
931	Metre	800	1463	22	10:33	3	27	NExN	Clear	NW	2	Choppy
932	Metre	900	1646	22	10.33	3	27	NExN	Clear	N	2	Moderate
933	Metre	600	1097	23	9 10	4	00	SW	Clear	N	1	Moderate
934	Metre	700	1280	23	9 10	4	00	SW	Clear	N	1	Moderate
935	Metre	800	1463	23	9 10	4	00	SW	Clear	N	1	Moderate
936	Metre	1000	1829	23	9 10	4	00	SW	Clear	N	1	Moderate
937	Metre	400	732	24	9 35	3	45	SSW	Misty	NE	2	Choppy
938	Metre	500	914	24	9:35	3	45	SSW	Misty	NE	2	Choppy
939	Metre	1000	1829	24	9·35	3	45	SSW	Misty	NE	2	Choppy
940	Metre	1000	1829	24	9·35	3	45	SSW	Misty	NE	2	Choppy
941	Metre	1000	1829	24	9.35	3	45	SSW	Misty	NE	2	Choppy
942	Metre	1000	1829	24	9.35	3	45	SSW	Misty	NE	2	Choppy
943	Metre	300	549	25	12·41PM	1	23	ESE	Overcast	N	2	Calm
944	Metre	400	732	25	12:41	1	23	ESE	Overcast	N	2	Calm
945	Metre	500	914	25	12·41	1	23	ESE	Overcast	N	2	Calm
946	Metre	600	1097	25	12.41	1	23	ESE	Overcast	N	2	Calm
947	Metre	700	1280	25	12:41	1	23	ESE	Overcast	N	2	Calm
948	Metre	400	732	26	9·34AM	3	43	SWxS	Overcast	W	1	Moderate
949	Metre	800	1463	26	9:34	3	43	SWxS	Overcast	W	1	Moderate
950	Metre	900	1646	26	9:34	3	54	SWxS	Overcast	W	1	Moderate
951	Metre	900	1646	26	9:34	3	54	SWxS	Overcast	W	1	Moderate
952	Metre	1000	1829	26	9:34	3	54	SWxS	Overcast	W	1	Moderate
953	Metre	1000	1829	26	9:34	3	54	SWxS	Overcast	W	1	Moderate
954	Metre	1000	1829	26	9:34	3	54	SWxS	Overcast	W	1	Moderate
955	4'Dr	1000	3000	28	9:15	2	15	S	Clear	NE	1	Calm
956	4'Dr	1000	3000	28	12:45PM	2	21	SE	Clear	NE	1	Calm
957	Metre	300	549	29	9:36AM	3	54	SE to S	Squally	N	1	Calm

INDIVIDUAL NETS AND DATA—*Continued*

Net No.	Type of Net	Depth		Date 1930	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				Sept.		H	M					
958	Metre	400	732	29	9:36AM	3	54	SE to S	Squally	N	1	Calm
959	Metre	500	914	29	9:36	3	54	SE to S	Squally	N	1	Calm
960	Metre	600	1097	29	9:36	3	54	SE to S	Squally	N	1	Calm
961	Metre	700	1280	29	9·36	3	54	SE to S	Squally	N	1	Calm
962	Metre	800	1463	29	9:36	3	54	SE to S	Squally	N	1	Calm
963	Metre	900	1646	29	9:36	3	54	SE to S	Squally	N	1	Calm
964	1 Diat	600	1097	29	9.36	3	54	SE to S	Squally	N	1	Calm
965	Metre	300	549	30	9:30	4	30	E to N	Clear	SE	1	Calm
966	Metre	400	732	30	9:30	4	30	E to N	Clear	SE	1	Calm
967	Metre	500	914	30	9:30	4	30	E to N	Clear	SE	1	Calm
968	Metre	700	1280	30	9:30	4	30	E to N	Clear	SE	1	Calm
969	Metre	800	1463	30	9:30	4	30	E to N	Clear	SE	1	Calm
970	Metre	1000	1829	30	9.30	4	30	E to N	Clear	SE	1	Calm
971	Metre	1000	1829	30	9:30	4	30	E to N	Clear	SE	1	Calm
972	1 Diat	900	1646	30	9:30	4	30	E to N	Clear	SE	1	Calm
973		0	0	30	9:30	4	30	E to N	Clear	SE	1	Calm
				Oct.								
974	½Metre	100	183	8	10:24		40	E	Clear	NNE	2	Rough
975	Metre	0	0	12	9 00	3	00	E	Clear	NE	1	Moderate
976	Metre	0	0	12	2·00	2	00	E	Clear	NE	1	Moderate

BERMUDA OCEANOGRAPHIC EXPEDITIONS

INDIVIDUAL NETS AND DATA*

1931

By WILLIAM BEEBE

Nets by Vertical Distribution—1931

	May	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Total*
Surface	6	6	1	4	2	..	8	27
25	..	3	4	..	2	..	..	9
50	..	2	8	..	4	..	..	14
100	..	3	5	..	3	..	..	11
200	..	4	4	..	1	..	..	9
300	..	6	23	2	5	..	..	36
400	..	3	5	9	3	..	..	20
500	..	7	3	18	10	2	..	40
600	..	6	4	16	10	2	..	38
700	..	7	3	18	10	2	..	40
800	..	7	3	20	10	2	..	42
900	..	6	4	17	10	2	..	39
1000	..	5	3	23	10	2	..	43
1100	..	..	..	..	1	..	..	1
1200	..	..	..	..	..	..	..	..
1300	..	..	..	..	..	..	..	..
1400	..	1	..	..	..	..	..	1
1500	..	..	..	1	2	..	..	3
2000	..	..	..	..	1	..	..	1
TOTAL	6	66	70	128	84	12	8	374

General Summary of Vertical Distribution of 1350 Nets (1929, 1930, 1931)

Surface	113	800	174
25	9	900	174
50	14	1000	178
100	21	1100	5
200	21	1200	1
300	59	1400	1
400	60	1500	3
500	172	2000	1
600	172		
700	172	TOTAL	1350

*Contribution, New York Zoological Society, Department of Tropical Research. No. 366.

INDIVIDUAL NETS AND DATA

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1931	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				May								
977	Metre	0	0	12	8:05PM		25	S to SE	Overcast	E	1	Swell
978	Metre	0	0	15	8:15		25	SE	No moon	SE	3	Choppy
979	Metre	0	0	16	8:10		20	S to N	No moon	SE	1	Calm
980	Metre	0	0	17	8:05	1	0	S to N	No moon	SE	1	Choppy
981	Metre	0	0	18	9:55		30	SE	No moon	O	0	Calm
982	Metre	0	0	19	9:00		30	NW	No moon	SE	2	Choppy
				June								
983	Metre	500	914	2	10:00AM	4	1	SE	Clear	SW	4	Choppy
984	Metre	600	1097	2	10:00	4	1	SE	Clear	SW	4	Choppy
985	Metre	700	1280	2	10:00	4	1	SE	Clear	SW	4	Choppy
986	Metre	800	1463	2	10:00	4	1	SE	Clear	SW	4	Choppy
987	Metre	900	1646	2	10:00	4	1	SE	Clear	SW	4	Choppy
988	Metre	1000	1829	2	10:00	4	1	SE	Clear	SW	4	Choppy
989	Metre	0	0	3	8:25PM		35	SE	No moon	NxE	3	Choppy
990	Metre	500	914	4	9:30AM	4	5	E	Clear	N	2	Moderate
991	Metre	600	1097	4	9:30	4	5	E	Clear	N	2	Moderate
992	Metre	700	1280	4	9:30	4	5	E	Clear	N	2	Moderate
993	Metre	800	1463	4	9:30	4	5	E	Clear	N	2	Moderate
994	Metre	900	1646	4	9:30	4	5	E	Clear	N	2	Moderate
995	Metre	1000	1829	4	9:30	4	5	E	Clear	N	2	Moderate
996	Metre	400	732	5	9:15	4	10	SxW	Clear	W	2	Moderate
997	Metre	500	914	5	9:15	4	10	SxW	Clear	W	2	Moderate
998	Metre	600	1097	5	9.15	4	10	SxW	Clear	W	2	Moderate
999	Metre	700	1280	5	9:15	4	10	SxW	Clear	W	2	Moderate
1000	Metre	700	1280	5	9:15	4	10	SxW	Clear	W	2	Moderate
1001	Metre	800	1463	5	9.15	4	10	SxW	Clear	W	2	Moderate
1002	Metre	300	549	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1003	Metre	500	914	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1004	Metre	600	1097	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1005	Metre	700	1280	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1006	Metre	800	1463	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1007	Metre	800	1463	6	9:20	4	10	SSW	Clear	NW	3	Moderate
1008	Metre	600	1097	11	9:20	3	50	E	Overcast	SW	4	Choppy
1009	Metre	900	1646	11	9:20	3	50	E	Overcast	SW	4	Choppy
1010	Metre	900	1646	11	9:20	3	50	E	Overcast	SW	4	Choppy
1011	Metre	1000	1829	11	9:20	3	50	E	Overcast	SW	4	Choppy
1012	Metre	1000	1829	11	9:20	3	50	E	Overcast	SW	4	Choppy
1013	Wire Metre	400	732	12	9:00	1		SSE	Overcast	NW	5	Rough
1014	Wire Metre	500	914	13	9:00	1	25	ESE	Overcast	W	4	Rough
1015	Metre	500	914	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1016	Metre	500	914	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1017	Metre	900	1646	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1018	Metre	900	1646	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1019	Metre	1000	1829	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1020	Metre	1400	2562	15	9:45	4	5	SSW	Overcast	NW	4	Choppy
1021	Metre	600	1097	16	9:17	4	0	SE	Overcast	NW	1	Calm
1022	Metre	700	1280	16	9:17	4	0	SE	Overcast	NW	1	Calm
1023	Metre	700	1280	16	9:17	4	0	SE	Overcast	NW	1	Calm

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth		Date 1931	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				June		H	M					
1024	Metre	800	1463	16	9:17AM	4	0	SE	Overcast	NW	1	Calm
1025	Metre	800	1463	16	9:17	4	0	SE	Overcast	NW	1	Calm
1026	Metre	1000	1829	16	9:17	4	0	SE	Overcast	NW	1	Calm
1027	Metre	0	0	17	8:30PM		40	N	Overcast	SW	2	Choppy
1028	Metre	0	0	20	9:20		30	SW	Moonlight	O	0	Calm
1029	Wire 2 Metre	200	366	22	10:30AM	1	50	NW	Clear	SW	1	Calm
1030	Wire 2 Metre	400	732	22	1:20PM	1	25	SE	Clear	SW	1	Calm
1031	Metre	0	0	23	9:08AM	5	0	SW	Clear	SW	1	Calm
1032	Metre	25	45	23	9:08	5	0	SW	Clear	SW	1	Calm
1033	Metre	200	366	23	9:08	5	0	SW	Clear	SW	1	Calm
1034	Metre	300	549	23	9:08	5	0	SW	Clear	SW	1	Calm
1035	Metre	100	183	25	9:06	4	39	SW	Clear	NW	4	Choppy
1036	Metre	200	366	25	9:06	4	39	SW	Clear	NW	4	Choppy
1037	Metre	300	549	25	9:06	4	39	SW	Clear	NW	4	Choppy
1038	Metre	300	549	25	9:06	4	39	SW	Clear	NW	4	Choppy
1039	Metre	0	0	26	8:50	4	10	ESE	Overcast	E	4	Rough
1040	Metre	25	45	26	8:50	4	10	ESE	Overcast	E	4	Rough
1041	Metre	50	92	26	8:50	4	10	ESE	Overcast	E	4	Rough
1042	Metre	100	183	26	8:50	4	10	ESE	Overcast	E	4	Rough
1043	Metre	300	549	26	8:50	4	10	ESE	Overcast	E	4	Rough
1044	Metre	0	0	27	8:40	4	0	Circle	Overcast	SE	3	Moderate
1045	Metre	25	45	27	8:40	4	0	Circle	Overcast	SE	3	Moderate
1046	Metre	50	92	27	8:40	4	0	Circle	Overcast	SE	3	Moderate
1047	Metre	100	183	27	8:40	4	0	Circle	Overcast	SE	3	Moderate
1048	Metre	300	549	27	8:40	4	0	Circle	Overcast	SE	3	Moderate
				July								
1049	Metre	0	0	6	8:38	5	5	SW	Clear	NE	4	Choppy
1050	Metre	25	45	6	8:38	5	5	SW	Clear	NE	4	Choppy
1051	Metre	50	92	6	8:38	5	5	SW	Clear	NE	4	Choppy
1052	Metre	300	549	6	8:38	5	5	SW	Clear	NE	4	Choppy
1053	Metre	300	549	6	8:38	5	5	SW	Clear	NE	4	Choppy
1054	Metre	25	45	7	8:40	5	0	NW	Clear	NE	2	Moderate
1055	Metre	50	92	7	8:40	5	0	NW	Clear	NE	2	Moderate
1056	Metre	50	92	7	8:40	5	0	NW	Clear	NE	2	Moderate
1057	Metre	100	183	7	8:40	5	0	NW	Clear	NE	2	Moderate
1058	Metre	300	549	7	8:40	5	0	NW	Clear	NE	2	Moderate
1059	Metre	100	183	8	8:40	5	0	ESE	Clear	E	2	Calm
1060	Metre	200	366	8	8:40	5	0	ESE	Clear	E	2	Calm
1061	Metre	300	549	8	8:40	5	0	ESE	Clear	E	2	Calm
1062	Metre	300	549	8	8:40	5	0	ESE	Clear	E	2	Calm
1063	Metre	300	549	8	8:40	5	0	ESE	Clear	E	2	Calm
1064	Metre	100	183	9	9:09	4	32	E	Clear	SE	4	Swell
1065	Metre	200	366	9	9:09	4	32	E	Clear	SE	4	Swell
1066	Metre	300	549	9	9:09	4	32	E	Clear	SE	4	Swell
1067	Metre	300	549	9	9:09	4	32	E	Clear	SE	4	Swell
1068	Metre	300	549	9	9:09	4	32	E	Clear	SE	4	Swell
1069	Metre	50	92	10	8:40	4	50	W	Clear	S	2	Swell

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth		Date 1931	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				July		H	M					
1070	Metre	300	549	10	8:40AM	4	50	W	Clear	S	2	Swell
1071	Metre	300	549	10	8:40	4	50	W	Clear	S	2	Swell
1072	Metre	300	549	10	8:40	4	50	W	Clear	S	2	Swell
1073	Metre	300	549	10	8:40	4	50	W	Clear	S	2	Swell
1074	Metre	25	45	11	8:46	5	46	E	Clear	SE	3	Swell
1075	Metre	50	92	11	8:46	5	46	E	Clear	SE	3	Swell
1076	Metre	300	549	11	8:46	5	46	E	Clear	SE	3	Swell
1077	Metre	300	549	11	8:46	5	46	E	Clear	SE	3	Swell
1078	Metre	300	549	11	8:46	5	46	E	Clear	SE	3	Swell
1079	Metre	50	92	14	8:50	5	40	SW	Clear	S	2	Calm
1080	Metre	100	183	14	8:50	5	40	SW	Clear	S	2	Calm
1081	Metre	200	366	14	8:50	5	40	SW	Clear	S	2	Calm
1082	Metre	300	549	14	8:50	5	40	SW	Clear	S	2	Calm
1083	Metre	300	549	14	8:50	5	40	SW	Clear	S	2	Calm
1084	Metre	25	45	15	8:50	5	25	E to NE	Overcast	SW	1	Calm
1085	Metre	50	92	15	8:50	5	25	E to NE	Overcast	SW	1	Calm
1086	Metre	300	549	15	8:50	5	25	E to NE	Overcast	SW	1	Calm
1087	Metre	300	549	15	8:50	5	25	E to NE	Overcast	SW	1	Calm
1088	Metre	300	549	15	8:50	5	25	E to NE	Overcast	SW	1	Calm
1089	Metre	50	92	18	8:57	2	33	SW to E	Squally	W	4	Swell
1090	Metre	100	183	18	8:57	2	33	SW to E	Squally	W	4	Swell
1091	Metre	200	366	18	8:57	2	33	SW to E	Squally	W	4	Swell
1092	Metre	300	549	18	8:57	2	33	SW to E	Squally	W	4	Swell
1093	Metre	300	549	18	8:57	2	33	SW to E	Squally	W	4	Swell
1094	Metre	400	732	24	9:17	4	58	ESE	Clear	SW	1	Calm
1095	Metre	600	1097	24	9:17	4	58	ESE	Clear	SW	1	Calm
1096	Metre	700	1280	24	9:17	4	58	ESE	Clear	SW	1	Calm
1097	Metre	700	1280	25	9:17	4	58	ESE	Clear	SW	1	Calm
1098	Metre	900	1646	24	9:17	4	58	ESE	Clear	SW	1	Calm
1099	Metre	900	1646	24	9:17	4	58	ESE	Clear	SW	1	Calm
1100	Metre	1000	1829	24	9:17	4	58	ESE	Clear	SW	1	Calm
1101	Metre	400	732	25	9:30	4	10	S	Overcast	S	1	Calm
1102	Metre	500	914	25	9:30	4	10	S	Overcast	S	1	Calm
1103	Metre	600	1097	25	9:30	4	10	S	Overcast	S	1	Calm
1104	Metre	700	1280	25	9:30	4	10	S	Overcast	S	1	Calm
1105	Metre	800	1463	25	9:30	4	10	S	Overcast	S	1	Calm
1106	Metre	900	1646	25	9:30	4	10	S	Overcast	S	1	Calm
1107	Metre	400	732	27	9:30	4	0	SW	Overcast	SW	1	Calm
1108	Metre	500	914	27	9:30	4	0	SW	Overcast	SW	1	Calm
1109	Metre	600	1097	27	9:30	4	0	SW	Overcast	SW	1	Calm
1110	Metre	600	1097	27	9:30	4	0	SW	Overcast	SW	1	Calm
1111	Metre	800	1463	27	9:30	4	0	SW	Overcast	SW	1	Calm
1112	Metre	900	1646	27	9:30	4	0	SW	Overcast	SW	1	Calm
1113	Metre	400	732	29	9:34	4	11	ESE	Clear	S	1	Calm
1114	Metre	400	732	29	9:34	4	11	ESE	Clear	S	1	Calm
1115	Metre	500	914	29	9:34	4	11	ESE	Clear	S	1	Calm
1116	Metre	800	1463	29	9:34	4	11	ESE	Clear	S	1	Calm
1117	Metre	1000	1829	29	9:34	4	11	ESE	Clear	S	1	Calm
1118	Metre	1000	1829	29	9:34	4	11	ESE	Clear	S	1	Calm

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth		Date 1931	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres							Direction	Force	
				Aug.		H	M					
1119	Metre	400	732	3	9:08AM	4	33	E	Overcast	NW	1	Moderate
1120	Metre	400	732	3	9:08	4	33	E	Overcast	NW	1	Moderate
1121	Metre	500	914	3	9:08	4	33	E	Overcast	NW	1	Moderate
1122	Metre	600	1097	3	9:08	4	33	E	Overcast	NW	1	Moderate
1123	Metre	700	1280	3	9:08	4	33	E	Overcast	NW	1	Moderate
1124	Metre	800	1463	3	9:08	4	33	E	Overcast	NW	1	Moderate
1125	Metre	400	732	4	9:24	4	6	SxW	Clear	NE	1	Calm
1126	Metre	400	732	4	9:24	4	6	SxW	Clear	NE	1	Calm
1127	Metre	900	1646	4	9:24	4	6	SxW	Clear	NE	1	Calm
1128	Metre	1000	1829	4	9:24	4	6	SxW	Clear	NE	1	Calm
1129	Metre	1000	1829	4	9:24	4	6	SxW	Clear	NE	1	Calm
1130	Metre	1000	1829	4	9:24	4	6	SxW	Clear	NE	1	Calm
1131	Metre	500	914	5	9:20	4	20	ESE	Clear	0	0	Calm
1132	Metre	600	1097	5	9:20	4	20	ESE	Clear	0	0	Calm
1133	Metre	700	1280	5	9:20	4	20	ESE	Clear	0	0	Calm
1134	Metre	800	1463	5	9:20	4	20	ESE	Clear	0	0	Calm
1135	Metre	900	1646	5	9:20	4	20	ESE	Clear	0	0	Calm
1136	Metre	1000	1829	5	9:20	4	20	ESE	Clear	0	0	Calm
1137	Metre	600	1097	6	8:55	4	5	SSW	Overcast	W	2	Moderate
1138	Metre	600	1097	6	8:55	4	4	SSW	Overcast	W	2	Moderate
1139	Metre	700	1280	6	8:55	4	5	SSW	Overcast	W	2	Moderate
1140	Metre	700	1280	6	8:55	4	5	SSW	Overcast	W	2	Moderate
1141	Metre	800	1463	6	8:55	4	5	SSW	Overcast	W	2	Moderate
1142	Metre	800	1463	6	8:55	4	5	SSW	Overcast	W	2	Moderate
1143	Metre	500	914	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1144	Metre	500	914	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1145	Metre	600	1097	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1146	Metre	600	1097	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1147	Metre	700	1280	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1148	Metre	700	1280	7	9:00	4	0	E to NE	Clear	NW	2	Moderate
1149	Metre	500	914	8	8:55	4	35	E	Overcast	0	0	Calm
1150	Metre	500	914	8	8:55	4	35	E	Overcast	0	0	Calm
1151	Metre	600	1097	8	8:55	4	35	E	Overcast	0	0	Calm
1152	Metre	600	1097	8	8:55	4	35	E	Overcast	0	0	Calm
1153	Metre	700	1280	8	8:55	4	35	E	Overcast	0	0	Calm
1154	Metre	700	1280	8	8:55	4	35	E	Overcast	0	0	Calm
1155	Metre	400	732	10	9:12	4	3	SW	Clear	W	3	Moderate
1156	Metre	500	914	10	9:12	4	3	SW	Clear	W	3	Moderate
1157	Metre	500	914	10	9:12	4	3	SW	Clear	W	3	Moderate
1158	Metre	600	1097	10	9:12	4	3	SW	Clear	W	3	Moderate
1159	Metre	700	1280	10	9:12	4	3	SW	Clear	W	3	Moderate
1160	Metre	800	1463	10	9:12	4	3	SW	Clear	W	3	Moderate
1161	Metre	500	914	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1162	Metre	800	1463	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1163	Metre	800	1463	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1164	Metre	800	1463	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1165	Metre	900	1646	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1166	Metre	900	1646	11	9:15	4	25	SSW	Overcast	SW	2	Moderate
1167	Metre	500	914	12	9:42	4	18	ESE	Overcast	SE	2	Swell
1168	Metre	600	1097	12	9:42	4	18	ESE	Overcast	SE	2	Swell

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1931	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Aug.		H	M					
1169	Metre	700	1280	12	9:42AM	4	18	ESE	Overcast	SE	2	Swell
1170	Metre	800	1463	12	9:42	4	18	ESE	Overcast	SE	2	Swell
1171	Metre	900	1646	12	9:42	4	18	ESE	Overcast	SE	2	Swell
1172	Metre	1000	1829	12	9:42	4	18	ESE	Overcast	SE	2	Swell
1173	Metre	400	732	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1174	Metre	500	914	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1175	Metre	600	1097	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1176	Metre	700	1280	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1177	Metre	800	1463	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1178	Metre	900	1646	14	9:20	3	0	ESE	Overcast	NE	4	Rough
1179	Metre	0	0	14	8:30PM		30	S and N	No moon	SE	2	Calm
1180	Metre	500	914	15	9:20AM	4	0	E to NE	Clear	E	1	Swell
1181	Metre	600	1097	15	9:20	4	0	E to NE	Clear	E	1	Swell
1182	Metre	700	1280	15	9:20	4	0	E to NE	Clear	E	1	Swell
1183	Metre	800	1463	15	9:20	4	0	E to NE	Clear	E	1	Swell
1184	Metre	800	1463	15	9:20	4	0	E to NE	Clear	E	1	Swell
1185	Metre	900	1646	15	9:20	4	0	E to NE	Clear	E	1	Swell
1186	Metre	0	0	16	8:00PM		40	S	No moon	SW	1	Calm
1187	Metre	400	732	16	9:43AM	3	57	WSW	Overcast	W	2	Swell
1188	Metre	500	914	16	9:43	3	57	WSW	Overcast	W	2	Swell
1189	Metre	700	1280	16	9:43	3	57	WSW	Overcast	W	2	Swell
1190	Metre	900	1646	16	9:43	3	57	WSW	Overcast	W	2	Swell
1191	Metre	1000	1829	16	9:43	3	57	WSW	Overcast	W	2	Swell
1192	Metre	1000	1829	16	9:43	3	57	WSW	Overcast	W	2	Swell
1193	Metre	500	914	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1194	Metre	700	1280	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1195	Metre	800	1463	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1196	Metre	800	1463	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1197	Metre	1000	1829	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1198	Metre	1000	1829	17	9:45	4	15	E to NE	Overcast	N	2	Swell
1199	Metre	500	914	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1200	Metre	600	1097	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1201	Metre	800	1463	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1202	Metre	800	1463	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1203	Metre	900	1646	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1204	Metre	900	1646	19	9:49	3	51	SE to E	Overcast	SW	1	Swell
1205	Metre	700	1280	20	9:23	4	45	SW	Clear	SW	3	Swell
1206	Metre	800	1463	20	9:23	4	45	SW	Clear	SW	3	Swell
1207	Metre	900	1646	20	9:23	4	45	SW	Clear	SW	3	Swell
1208	Metre	900	1646	20	9:23	4	45	SW	Clear	SW	3	Swell
1209	Metre	1000	1829	20	9:23	4	45	SW	Clear	SW	3	Swell
1210	Metre	1000	1829	20	9:23	4	45	SW	Clear	SW	3	Swell
1211	Metre	300	549	21	10:55	1	40	E	Overcast	SW	4	Rough
1212	Metre	400	732	21	10:55	1	40	E	Overcast	SW	4	Rough
1213	Metre	900	1646	21	10:55	1	40	E	Overcast	SW	4	Rough
1214	Metre	1000	1829	21	10:55	1	40	E	Overcast	SW	4	Rough
1215	Metre	1000	1829	21	10:55	1	40	E	Overcast	SW	4	Rough
1216	Metre	1000	1829	21	10:55	1	40	E	Overcast	SW	4	Rough
1217	Metre	600	1097	24	9:40	3	56	SW	Overcast	SW	3	Swell
1218	Metre	700	1280	24	9:40	3	56	SW	Overcast	SW	3	Swell

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth		Date 1931	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind		Sea
		Fathoms	Metres			H	M			Direction	Force	
				Aug.								
1219	Metre	900	1646	24	9:40AM	3	56	SW	Overcast	SW	3	Swell
1220	Metre	1000	1829	24	9:40	3	56	SW	Overcast	SW	3	Swell
1221	Metre	1000	1829	24	9:40	3	56	SW	Overcast	SW	3	Swell
1222	Metre	1000	1829	24	9:40	3	56	SW	Overcast	SW	3	Swell
1223	Metre	0	0	24	8:20PM		30	Circle	Moonlight	SW	1	Calm
1224	4'Dr.	1500	2730	26	9:35AM		30	WSW	Clear	SW	1	Calm
1225	4'Dr.	1000	1829	26	1:20PM		30	WSW	Clear	SW	1	Calm
1226	Metre	300	549	27	9:16AM	4	19	WSW	Clear	SSW	1	Calm
1227	Metre	400	732	27	9:16	4	19	WSW	Clear	SSW	1	Calm
1228	Metre	500	914	27	9:16	4	19	WSW	Clear	SSW	1	Calm
1229	Metre	800	1463	27	9:16	4	19	WSW	Clear	SSW	1	Calm
1230	Metre	900	1646	27	9:16	4	19	WSW	Clear	SSW	1	Calm
1231	Metre	1000	1829	27	9:16	4	19	WSW	Clear	SSW	1	Calm
1232	Metre	0	0	27	8:00PM		20	S	Clear	SW	2	Calm
1233	4'Dr.	1000	1829	28	9:30AM		34	WSW	Clear	WSW	1	Calm
1234	4'Dr.	1000	1829	28	11:58		32	WSW	Clear	WSW	1	Calm
1235	Metre	500	914	29	9:27	4	23	SW	Overcast	W	1	Calm
1236	Metre	600	1097	29	9:27	4	23	SW	Overcast	W	1	Calm
1237	Metre	700	1280	29	9:27	4	23	SW	Overcast	W	1	Calm
1238	Metre	800	1463	29	9:27	4	23	SW	Overcast	W	1	Calm
1239	Metre	900	1646	29	9:27	4	23	SW	Overcast	W	1	Calm
1240	Metre	1000	1829	29	9:27	4	23	SW	Overcast	W	1	Calm
1241	Metre	500	914	31	9:33	4	2	E	Overcast	W	2	Swell
1242	Metre	600	1097	31	9:33	4	2	E	Overcast	W	2	Swell
1243	Metre	700	1280	31	9:33	4	2	E	Overcast	W	2	Swell
1244	Metre	800	1463	31	9:33	4	2	E	Overcast	W	2	Swell
1245	Metre	900	1646	31	9:33	4	2	E	Overcast	W	2	Swell
1246	Metre	1000	1829	31	9:33	4	2	E	Overcast	W	2	Swell
				Sept.								
1247	Metre	500	914	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1248	Metre	600	1097	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1249	Metre	700	1280	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1250	Metre	800	1463	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1251	Metre	900	1646	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1252	Metre	1000	1829	1	9:35	4	0	E to ENE	Overcast	NE	3	Swell
1253	Metre	0	0	1	7:30PM		30	S	Clear	SW	2	Calm
1254	Metre	500	914	3	9:10AM	4	25	E	Clear	E	1	Swell
1255	Metre	600	1097	3	9:10	4	25	E	Clear	E	1	Swell
1256	Metre	700	1280	3	9:10	4	25	E	Clear	E	1	Swell
1257	Metre	800	1463	3	9:10	4	25	E	Clear	E	1	Swell
1258	Metre	900	1646	3	9:10	4	25	E	Clear	E	1	Swell
1259	Metre	1000	1829	3	9:10	4	25	E	Clear	E	1	Swell
1260	Metre	500	914	4	9:26	4	14	SE to E	Clear	S	3	Swell
1261	Metre	600	1097	4	9:26	4	14	SE to E	Clear	S	3	Swell
1262	Metre	700	1280	4	9:26	4	14	SE to E	Clear	S	3	Swell
1263	Metre	800	1463	4	9:26	4	14	SE to E	Clear	S	3	Swell
1264	Metre	900	1646	4	9:26	4	14	SE to E	Clear	S	3	Swell
1265	Metre	1000	1829	4	9:26	4	14	SE to E	Clear	S	3	Swell
1266	4'Dr.	1500	2730	5	8:59		36	SW	Clear	SW	2	Calm
1267	4'Dr.	1500	2730	5	11:38		35	SW	Clear	SW	2	Calm

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1931	Start of Haul	Duration of Haul		Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Aug.		H	M					
1268	4'Dr.	1100	2002	5	2:09PM		31	SW	Overcast	SW	2	Calm
1269	Metre	0	0	4	8:00		20	SE	No moon	SW	2	Calm
1270	Metre	500	914	7	9:31AM	4	29	SW	Clear	SW	3	Moderate
1271	Metre	600	1097	7	9:31	4	29	SW	Clear	SW	3	Moderate
1272	Metre	700	1280	7	9:31	4	29	SW	Clear	SW	3	Moderate
1273	Metre	800	1463	7	9:31	4	29	SW	Clear	SW	3	Moderate
1274	Metre	900	1646	7	9.31	4	29	SW	Clear	SW	3	Moderate
1275	Metre	1000	1829	7	9:31	4	29	SW	Clear	SW	3	Moderate
1276	Metre	500	914	9	9:26	4	34	E to NE	Overcast	NW	2	Swell
1277	Metre	600	1097	9	9.26	4	34	E to NE	Overcast	NW	2	Swell
1278	Metre	700	1280	9	9.26	4	34	E to NE	Overcast	NW	2	Swell
1279	Metre	800	1463	9	9:26	4	34	E to NE	Overcast	NW	2	Swell
1280	Metre	900	1646	9	9:26	4	34	E to NE	Overcast	NW	2	Swell
1281	Metre	1000	1829	9	9:26	4	34	E to NE	Overcast	NW	2	Swell
1282	Metre	500	914	10	9 30	4	5	ESE	Clear	N	1	Calm
1283	Metre	600	1097	10	9:30	4	5	ESE	Clear	N	1	Calm
1284	Metre	700	1280	10	9·30	4	5	ESE	Clear	N	1	Calm
1285	Metre	800	1463	10	9.30	4	5	ESE	Clear	N	1	Calm
1286	Metre	900	1646	10	9:30	4	5	ESE	Clear	N	1	Calm
1287	Metre	1000	1829	10	9:30	4	5	ESE	Clear	N	1	Calm
1288	4'Dr.	2000	3640	11	12.54PM		36	NE	Clear	NE	3	Swell
1289	Wire Metre	300	549	11	3.15		30	N	Clear	NE	3	Swell
				Sept.		H	M					
1290	Metre	500	914	12	9:30AM	4	40	ESE	Clear	0	0	Calm
1291	Metre	600	1097	12	9·30	4	40	ESE	Clear	0	0	Calm
1292	Metre	700	1280	12	9:30	4	40	ESE	Clear	0	0	Calm
1293	Metre	800	1463	12	9:30	4	40	ESE	Clear	0	0	Calm
1294	Metre	900	1646	12	9:30	4	40	ESE	Clear	0	0	Calm
1295	Metre	1000	1829	12	9.30	4	40	ESE	Clear	0	0	Calm
1296	Metre	600	1097	14	9:48	4	17	ESE	Overcast	E	2	Swell
1297	Metre	700	1280	14	9.48	4	17	ESE	Overcast	E	2	Swell
1298	Metre	800	1463	14	9:48	4	17	ESE	Overcast	E	2	Swell
1299	Metre	900	1646	14	9.48	4	17	ESE	Overcast	E	2	Swell
1300	Metre	1000	1829	14	9:48	4	17	ESE	Overcast	E	2	Swell
1301	Metre	50	92	15	8:56	5	24	SW	Overcast	SE	3	Swell
1302	Metre	100	183	15	8:56	5	24	SW	Overcast	SE	3	Swell
1303	Metre	200	366	15	8:56	5	24	SW	Overcast	SE	3	Swell
1304	Metre	400	732	15	8:56	5	24	SW	Overcast	SE	3	Swell
1305	Metre	500	914	15	8:56	5	24	SW	Overcast	SE	3	Swell
1306	Metre	25	45	16	8:56	5	34	E	Clear	SE	1	Calm
1307	Metre	25	45	16	8:56	5	34	E	Clear	SE	1	Calm
1308	Metre	100	183	16	8:56	5	34	E	Clear	SE	1	Calm
1309	Metre	100	183	16	8:56	5	34	E	Clear	SE	1	Calm
1310	Metre	300	549	16	8:56	5	34	E	Clear	SE	1	Calm
1311	Metre	300	549	16	8:56	5	34	E	Clear	SE	1	Calm
1312	Metre	400	732	16	8:56	5	34	E	Clear	SE	1	Calm
1313	Metre	500	914	17	9.19	4	41	SE to NE	Clear	E	1	Calm
1314	Metre	600	1097	17	9.19	4	41	SE to NE	Clear	E	1	Calm
1315	Metre	700	1280	17	9·19	4	41	SE to NE	Clear	E	1	Calm

INDIVIDUAL NETS AND DATA — *Continued*

Net No.	Type of Net	Depth Fathoms	Depth Metres	Date 1931	Start of Haul	Duration of Haul H	Duration of Haul M	Direction of Haul	Weather	Wind Direction	Wind Force	Sea
				Aug.		H	M					
1316	Metre	800	1463	17	9:19AM	4	41	SE to NE	Clear	E	1	Calm
1317	Metre	900	1646	17	9:19	4	41	SE to NE	Clear	E	1	Calm
1318	Metre	1000	1829	17	9:19	4	41	SE to NE	Clear	E	1	Calm
1319	Metre	25	45	18	12:50PM	2	10	NE	Clear	E	2	Calm
1320	Metre	25	45	18	12:50	2	10	NE	Clear	E	2	Calm
1321	Metre	50	92	18	12:50	2	10	NE	Clear	E	2	Calm
1322	Metre	300	549	18	12:50	2	10	NE	Clear	E	2	Calm
1323	Metre	300	549	18	12:50	2	10	NE	Clear	E	2	Calm
1324	Metre	400	732	18	12:50	2	10	NE	Clear	E	2	Calm
1325	Metre	500	914	19	10:18AM	4	42	NExE	Overcast	W	3	Rough
1326	Metre	600	1097	19	10:18	4	42	NExE	Overcast	W	3	Rough
1327	Metre	700	1280	19	10:18	4	42	NExE	Overcast	W	3	Rough
1328	Metre	800	1463	19	10:18	4	42	NExE	Overcast	W	3	Rough
1329	Metre	900	1646	19	10:18	4	42	NExE	Overcast	W	3	Rough
1330	Metre	1000	1829	19	10:18	4	42	NExE	Overcast	W	3	Rough
				Oct.								
1331	Metre	500	914	28	9:22	4	42	SW	Clear	N	4	Swell
1332	Metre	600	1097	28	9:22	4	42	SW	Clear	N	4	Swell
1333	Metre	800	1463	28	9:22	4	42	SW	Clear	N	4	Swell
1334	Metre	900	1646	28	9:22	4	42	SW	Clear	N	4	Swell
1335	Metre	1000	1829	28	9:22	4	42	SW	Clear	N	4	Swell
1336	Metre	500	914	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1337	Metre	600	1097	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1338	Metre	700	1280	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1339	Metre	700	1280	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1340	Metre	800	1463	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1341	Metre	900	1646	29	9:27	4	35	SxW	Overcast	S	3	Choppy
1342	Metre	1000	1829	29	9:27	4	35	SxW	Overcast	S	3	Choppy
				Nov.		H	M					
1343	Metre	0	0	2	7:30PM		20	S	No moon	S	2	Moderate
1344	Metre	0	0	3	7:30		20	N	Overcast	SW	3	Rough
1345	Metre	0	0	12	7:30		30	S	No moon	0	0	Calm
1346	Metre	0	0	12	8:00		30	N	No moon	0	0	Calm
1347	Metre	0	0	13	7:30		30	S	Moonlight	0	0	Calm
1348	Metre	0	0	13	8:00		30	N	Moonlight	0	0	Calm
1349	Metre	0	0	15	7:30		30	S	Moonlight	0	0	Calm
1350	Metre	0	0	17	3:30AM	1	0	S	No moon	S	2	Calm

NINETEEN NEW SPECIES AND FOUR POST-LARVAL DEEP-SEA FISH*

By WILLIAM BEEBE

(Figs. 8-31 incl.)

This is the first installment of descriptions of new forms of fish taken on the Bermuda Oceanographic Expeditions of the Department of Tropical Research of the New York Zoological Society. They were all taken within the eight-mile circle whose center is at 32° 12′ North Latitude and 64° 36′ West Longitude, nine and one quarter miles south-southeast of Nonsuch Island, Bermuda.

LIST OF SPECIES

**Contribution, New York Zoological Society, Department of Tropical Research, No. 367.*

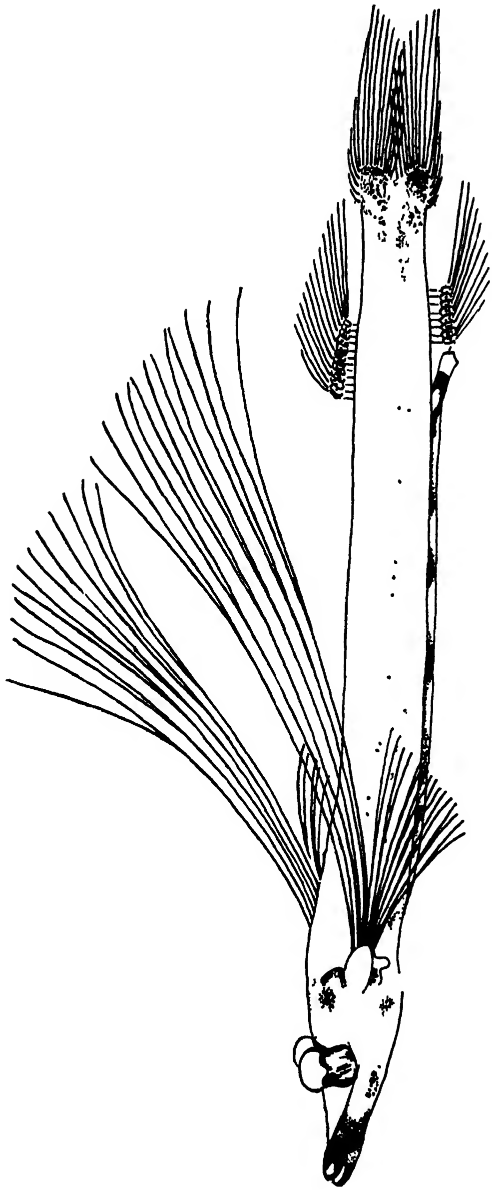


Fig. 8. *Dolichopteryx binocularis* sp. nov.

Dolichopteryx binocularis sp. nov.

Type: No. 21,867, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1125; *August* 4, 1931; 14 *miles southeast of Nonsuch, Bermuda;* 400 *fathoms; standard length* 85 *mm.*

Field Characters: An elongate, telescope-eyed fish, with very small mouth, exceedingly slender and elongate pectoral rays; scaleless except on lateral line, white and transparent above, with considerable dark pigment below: ventrals and vertical fins far aft on the body.

Measurements and Counts: Total length 101 mm.; standard length 85 mm.; depth 5 (in length 17); head 17 (in length 5); eye diameter 3.1 (in head 5.5); snout 7.1 (in head 2.4); mouth horizontal; eyes slanted 10° forward from the vertical; pectoral 6 + 8 = 14; pectoral length 55 mm.; ventral 3 + 6 = 9; ventral length 15; dorsal 15; anal 11; caudal XIII — 9 — 9 — XIV; caudal length 16 mm.

General Description: The fish as a whole appears as transparent white, with dark muzzle, five large, ventral blotches, and a midline of dark chromatophores.

The upper lip is white, the jaws solidly dusky, thinning into individual, black, round chromatophores back almost to the eyes; this pigment is close over the bone of the jaws, far beneath the outer, white, transparent skin; directly below the eyes are fourteen large, purplish, dendritic chromatophores, six in a straight row, the others in a bow shape below; on the side of the midbrain and back of the hind brain are solid masses of almost fused, black chromatophores; a large, triangular patch of many, very small ones over the lower angle of the gill arches; another large patch of disconnected ones directly over the heart which lies just below the pectorals; on the ventral surface are five dense patches of black showing purple glints; the fourth merges with the fifth far back beneath the ventrals; along the midline of the body a single row of iridescent or black chromatophores; these are arranged into successive groups, the more anterior of three to five chromatophores; from the midbody back the groups increase in number of components—five to ten—each group forming a short, oblique line, at a slight downward angle; midway between this line and the back is a second line of a very few, widely spread, large chromatophores, twenty-two altogether, quite irregular as regards spacing, two together or singly; from halfway between the end of the dorsal and the caudal the parallel-sided peduncle is thickly peppered with large and small, sepa-

rate, dendritic chromatophores, there being a clear space along the midline.

The body of the fish is elongate, with very little change in calibre throughout, the dorsal and ventral surfaces nearly parallel, the head narrows slowly into a broad, rounded muzzle, the eyes projecting well above the profile. The eyes rest in a great depression of the head, the upper part being covered with perfectly transparent tissue; the nostrils are round, close together, and about four-fifths the way to the snout from the eye; the eyes are very large, once and a half as high as wide, the stalk thick, short, dark, the summits clear, swollen and rounded; they are placed very close alongside each other, and slant forward 10° from the vertical; the eyeballs are overlaid on the front and outer side with longitudinal, prismatic, spicule scales, giving off blue, green and bronze reflections. On the outside the black of the eyeball extends upward in a rounded bay, which carries a large photophore, opening obliquely down and back in a silvery trough. The base of the eye-ball rests in a shallow saucer of silver spicules.

The mouth is very small, horizontal; the teeth are very indistinct in the uncleared specimen.

The dorsal fin arises high above the surface of the body, from a framework supporting an oval muscle and a tall baseost for each ray; forward the free skin stretches for a considerable distance, and posteriorly the high, free, transparent skin connects with the supra-caudal spines; the anal is similar in origin and the muscles of each fin have a scattering of black chromatophores along their sides.

The pectoral fins show a large, fleshy, basal pad, with a sharply oblique posterior rim, from which arise fourteen rays; the upper six are, in the fresh fish, directed straight back or slightly upward, and in this individual new-caught fish the first and sixth left rays and the first and third right rays were bent but still showed full length. They split into two about half-way of their length, and reached to half-way down the anal, or 55 mm. The lower eight were directed obliquely downward, showing a distinct break between the two, and were about equal in length, the largest being only 4.3 mm or one-fourteenth of the upper rays. The ventral rays reached the caudal and measured 15 mm.

The epidermis along the ventral surface from the gills to the anus is loose, well away from the body, suspended by numerous thread-like supports, carrying an opaque band of luminous tissue. The eye-light

is pale white; the ventral organ gleams only with the faintest sheen in the new caught specimen.

Dyed and Cleared: In the dyed and cleared specimen structures become visible which are unsuspected in the fresh or preserved fish. The most unexpected is a row of 48 lateral line scales extending from the opercle to the caudal. The first, just above the base of the dorsal pectoral rays, is a well-ossified, thick, half circle, opening backward. The next 26 are very small, thin, slightly ossified and irregular, some almost straight, others three-fourths of a circle. The 27th scale occurs at 18.6 mm. in front of the dorsal. From here on the scales increase in size and thickness, and become circular. At the 40th, just over the ventral fins, they reach their largest size, the diameter keeping even for the succeeding scales to the last at the very base of the caudal. These are .86 mm. in outside, vertical diameter with a central oval opening .5 mm. in length. From the 40th on, the posterior rim of the central opening shows a slight thickening of osseous tissue, which increases and concentrates toward the center until, in the 51st, a slight projection is visible. In the last five this extends clear across the central hole as a knob-shaped projection, and a low spine develops on the outside.

Anteriorly the scales are five or six of their diameters apart, but they gradually approach until posteriorly the edges slightly overlap. They are placed equidistantly between the row of isolated chromatophores, and the inferior, dense line. And now we see that each curve, or oblique row marks an individual scale, this being true even to the very first. The clear midline space in the pigmented peduncle is now explained, for it is quite filled up with the lateral line scales.

There is a second, incomplete row of scales, beginning between the 40th and 41st, and extending to the caudal. These are placed close beneath the oblique lines of chromatophores, alternate with the upper row, and are much smaller, almost round and solid. These round scales are smaller anteriorly and increase slightly in size backward. There is a short row of 5 scales, similar to these, above the line of scattered chromatophores extending a short distance along the sides from the opercles. All the scales are very delicate and deciduous, a few falling off at each change of fluid in the clearing process.

There is a row of about thirty, very small, close set, incurved teeth in the lower jaw. In the upper there are four to five rows of teeth. Externally, on the cleared, outer surface of the lips and jaw

the bases of these can be distinguished as separately ossified, mosaic-like, irregularly arranged crescents or kidney-shaped bony plates. Within the jaw each of these gives rise to a long recurved tooth, all lying flat in a solid mass against the roof of the jaw.

Of the eleven anal rays, only eight have ossified baseosts, the two anterior and the posterior ray lacking a bony support.

The fifteen dorsals show twelve baseosts, the anterior and posterior rays lacking them. The 2nd and 3rd show a single, high, thickened, anteriorly directed bone. The 1st ray is very short and the two lateral bases are not joined, standing erect as two short, curved, erect spines.

In the cleared tissue the nine ventrals are seen to be divided sharply into two divisions, six lower, very fine rays, close together, and three superior rays, placed farther apart and more than twice as stout as the others.

The luminous, ventral band of tissue along the free epidermis is now seen to have a large number of very small tubercles.

Discussion: In "Discovery Reports" Volume II, p. 271, Norman has considered the Vailliant's and Brauer's specimens, and the two taken on the *Discovery* as all belonging to one species—*longipes*. This can probably be decided with certainty only from cleared and stained specimens. The present individual is, in many ways, closest to the Discovery specimens, but is set apart by several characters, two of which will serve for specific distinction. The depth to the length is 17 instead of 12 and the pectoral fins are set apart into two divisions, the upper six of great length, reaching to the mid-anal, and the lower eight only one-fourteenth as long.

Chirostomias lucidimanus sp. nov.

Type: No. 22,200, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1157; *August* 10, 1931; 10 *miles south of Nonsuch, Bermuda;* 500 *fathoms; standard length* 225 *mm.*

Field Characters: A fusiform black fish with short, thick barbel, bearing a tri-lobed bulb, with various tentacles and beaded projections, the anterior being a group of five, 3/5 as long as the whole stem; pectorals six, threadlike, frayed out into numerous, fine, luminous tendrils; dorsal 16, anal 22.

Measurements and Counts: Total length 235 mm.; standard length 225 mm.; depth 36 (in length 6.2); head 37 (in length 6); eye 6.4 (in head 5.8); snout 10.7 (in head 3.45); pectoral 6; pectoral length 83; ventrals 7; ventral length 17; dorsal 16; anal 22; caudal length 10; barbel stem 25; anterior terminal filaments 15.

General Description: Dorsal and ventral profiles almost parallel, sloping rather sharply toward the rounded snout, and very gradually toward the abruptly narrowed and short peduncle; adipose fin well developed. In one-half of the upper jaw are two large anterior canines, the second much the larger; behind the second canine and outside it a series of five medium-sized teeth begins, wide-spaced and ending halfway down the jaw, all outside the dental line; just behind and in a line with the second canine, the normal jaw teeth, all evenly-sized, extend to the gape, ten in number. The arrangement and size of the mandibular teeth are identical with those in the upper jaw. Every tooth has its small understudy companion, waiting to take its place when need arises. The illicium bulb is blue-black, elongate and somewhat compressed. The terminal part projects as two large tubular divisions, each tipped with a pair of sharp, tooth-like structures opening toward one another. The uppermost has a few very short tubercles at the tip, but the lower one is tipped with a long, beaded, luminous tentacle, while from the ventral side, five long (7.1 mm.) tentacles spring from a single base. These under ultra-violet light give out a pinkish glow. The dorsal surface of the bulb shows a number of isolated spots of luminous tissue which consolidate into a thick, luminous, white comb, smooth and rounded, with a slender, distal filament. The luminous tissue (white glow on this area) dies out on the surface of the mid-bulb in an ever-thinning mass of scattered spots and dots.

There is at least a single muscle at the tip of the bulb which has the power of separating widely the two terminal structures, the four teeth-like structures showing up strongly through the translucent pink luminous tissue

Lateral line of photophores: O-V 23, V-A 19 (7 of these above anal); ventral line: I-P 9, P-V 25, V-A 19 (6 of these above anal), A-C 10.

Comparison: I have taken four specimens of this form in the limited area in which I am trawling, measuring from 38.6 to 225 mm. standard length. They approach, in many particulars, Regan's *pliop-*

terus, but the eye is smaller in *lucidimanus* being only three-fifths as long as the snout, and 5.8 instead of 4 to 5 in the head; the dorsal is 16 instead of 18 to 20 and the ventrals are a full fifth nearer the caudal than to the eye.

The details of the bulb and its distal tentacles differ in the same degree in my small as in my large individuals and the same applies to the pectoral fins. As a contrast I have one small specimen of 35 mm. which is typically *pliopterus* in all its characters.

The only other recorded specimens are seven taken by the Dana. These were secured at depths of approximately 40 to 273 fathoms, and measure from 33 to 115 mm. standard length.

Eustomias schiffi sp. nov.

Type: No. 15,653, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 646; *May* 29, 1930; *six miles south of Nonsuch Island, Bermuda;* 600 *fathoms; standard length* 115 *mm.*

Measurements and Counts: Standard length 115 mm.; depth 9 (in length 12.7); head 14.3 (in length 8); eye 2.7 (in head 5.3); snout 5.4 (in head 2.6); pectoral 2; pectoral length 16.4; ventral 7; ventral length 18; dorsal 23; anal 37; caudal VII + 26 + V; caudal length 10.7; barbel length 57 (in length 2).

General Description: The body is slender and elongate; the back is parallel with the ventral outline, sloping gently posteriorly; with the upper jaw retracted the anterior profile is deeply indented, there is a very steep curve in front of the eye, then a thick dermal wrinkle and a straight line to the snout; the head is short, shallow and flattened ventrally; the snout is elongate, retracted, with a deep roll of skin rolled up from eye to eye around the mid-snout, formed by the posterior edge of the premaxillaries; the eyes show considerable projection above the head profile; nostrils are close together, rather large, close to the antero-superior margin of the eye; the mouth is large and slightly oblique; the maxillaries extend well behind the eye.

Teeth: There are 14 teeth in each premaxillary, a larger and a shorter pair close together at the very tip of the snout, then a space, then a large pair of fangs, and the rest smaller and irregular. The maxillary has 18 very small, oblique denticles. In the mandible there is a median pair of small teeth at the sypmphysis, and a very large pair

at the antero-exterior angle of the front of the jaw, followed by 15 more teeth, four of which are moderately large, making 17 altogether on each side of the lower jaw.

Skin: Appears black to the eye, rich dark brown under the lens, covered with an infinite number of minute photophores in areas arranged more or less in regular bands or patches. There is the usual arrangement of larger light organs on the head and body; a round, suborbital cheek-light is .57 mm. in diameter, showing a silvery white light. The two rows of body lights are dark purplish violet. The photophores show the following counts:

Ventral I-P 8, P-V 32, V-A 15, A-C 18; lateral P-V 34, V-15.

Fins: The vertical fins are typical of the Eustomiads, concentrated toward the caudal end, the three forming a unified, and the only, means of propulsion; the pectorals are non-natatory and non-luminous, wholly tactile in function; each is reduced to two elongated rays, longer than the head, with a transparent vein down each ray, like a slender leaf; the ventrals are one and a third times the length of the head, and similar to the pectorals except that all are delicately bound together by webbing; the longest rays reach well beyond the beginning of the anal fin; the caudal has two unequal lobes, the lower of which is the longer; there are 26 functional caudal rays.

Barbel: This elaborate organ is half as long as the standard length of the body. The stem is very long and slender with a thin core rather thickly speckled with small, black dendritic chromatophores, and two lines of dull red—not veins—extending down its entire length. Antero-posteriorly the stem expands into a gradually widening transparent area, then into a retort-shaped bulb, pale brown on the anterior or lower surface. This color changes abruptly into brilliant peacock blue on the body of the retort, and this in turn into turquoise back along the neck. This neck of the retort is drawn out into a transparent, slowly narrowing process, filled with a few oblong luminous granules. This process gives off about fifteen long thread-like tentacles, each with a central, single line of granules. The tentacles are transparent, the granules of the palest, blue green. Just before the beginning of the neck of the retort, a thick finger-like tentacle arises from the upper or posterior side, ending abruptly, with no appendages. From each side of this part of the retort arise branched processes like the larger terminal one, one large one on the left side, three lesser ones on the right,

these breaking up in turn into three to eight elongate, transparent threads.

Scattered along the transparent sheath of the long barbel stem are oval bodies, lying against the outer surface and all faintly ribbed, indicated by a slightly greater density. At the very base is a swollen, elongated scarlet body lying close to the core.

General Discussion: In Regan's Key of *Eustomias* (p. 75)* he lists *dubius* as "One bulb bearing two minute filaments", including in this Parr's type which terminates in a mutilated or regenerated flattened, irregular fan of tissue. Next on the list is *polyaster* with the definition "A small bulb proximal to main one, which bears a branched terminal appendage with bulb-like bodies in the stem."

The general heading of these two species "Pectoral of two rays," and "Barbel with a bulb divided by a distal notch into two equal lobes, the larger tapering" admits the present specimen, while the proportions bring it close to *dubius* and the barbel to *polyaster*. It is, however, very obviously distinct.

Eustomias schiffi differs from *dubius* in having 32 ventral P-V photophores, not 34 — 36; the barbel is ½ the length of the fish, not 2/7 to 1/3; and the barbel filaments are wholly different. From *polyaster* it differs in possessing only a single bulb instead of two to four, in the smaller number of ventral P-V photophores, and in having 14 instead of 11 teeth in the premaxillary.

I have named this species in memory of Mortimer Schiff whose interest in the work of this expedition was very deep and sincere.

Lamprotoxus angulifer sp. nov.

Type: No. 21,667, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1108; *July* 27, 1931; 15 *miles southeast of Nonsuch;* 500 *fathoms; standard length* 145 *mm.*

Field Characters: An elongate, black melanostomid, with long anterior fangs, elongate barbel, a long luminous line extending down the sides with a short, downward, anterior hook; a second labial line from snout half-way down jaw, and a curved luminous line from eye around to mid-jaw. Pectorals five, three with luminous tissue.

The Danish "Dana" Expedition, Report No. 6. 1930.

Measurements and Counts: Standard length 145; total 155; depth 18 (in length 8); head 25 (in length 5.8); eye 2.8 (in head 9), snout 4.3 (in head 5.8); mandible 22 (in head 1.1, in length 6.6); pectoral 5, pectoral length 7; ventral 7, ventral length 14.5; dorsal 21; anal 19 rays.

General Description: Body elongate, with rather straight, parallel contours, dorsal and anal fins far posterior, quite dominating and with much of the function of the caudal; head moderate with the usual enormous opercular opening of this group; a somewhat short, swollen snout, once and a half the diameter of the rather small eye; nostrils round, close together, nearer eye than snout; mouth large, jaws straight.

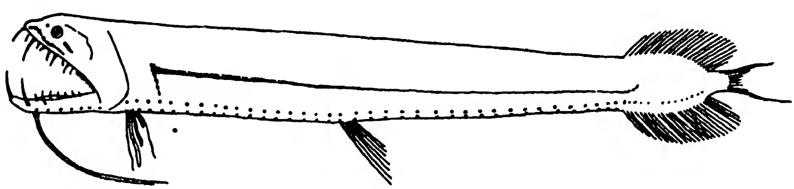


Fig. 9. *Lamprotoxus angulifer* sp. nov.

Teeth: At the tip of the premaxillary is a very long, strong pair of fangs, and following there is a line of five pairs of sharp teeth lying outside the dental ridge, the 1st and 5th twice as long as the others; along the ridge are ten teeth in each half jaw, the anterior pair very long. In front of the mandible is the longest pair of teeth to be found in the jaws. At wide, equal distances along the jaw are two more pairs of fangs, large and curved, all three pairs lying well outside the dental line. Inside of these are about fifteen teeth of varying size, scattered along each mandibular ramus. There are three pairs of small teeth on the palatines.

Skin: The skin is smooth, blackish brown, with the usual segments marked off by lines of black pigment.

The barbel is broken off at 13 mm. from the base, but was probably simple and of considerably greater length, as in *Lamprotoxus flagellibarba*.

Photophores: There is a moderate sized, narrowly pyriform, silvery cheek light behind the eye, 1.4 mm. in length, in a frame 2.4 mm.

long. The fish is covered from snout to tail with hundreds of very minute photophores pale pinkish in color, but like the larger ones in everything but size and regularity of position.

The lateral row of body photophores shows the following arrangement, O-V 16, V-A 22, A-C 12; the ventral ones I-P 7, P-V 17, V-A 19.

The lights on the branchiostegals are pale violet, those along the body deeper purple, with very large, concave gold caps.

Luminous Tissue: There is a very definite pattern of white, luminous tissue along the sides of the body in the shape of a long-handled, angled crook, the anterior part of which is formed by a solid line such as I have found in *L. flagellibarba.* The crook extends straight downward close to the posterior edge of the gill opening, breaking up into several, elongate spots toward the end. The handle extends down the midline, halfway the length of the anal. It consists of two divisions, a ventral, solid line for much of the distance, and a dorsal line, very close to it of small separate spots. The line becomes single at the level of the tenth lateral photophore beyond the ventral fin.

Besides this there is an almost solid line of luminous tissue from the tip of the snout down each side of the upper lip to a level with the middle of the eye, and a third, very thin, wavering but solid line arising back of the eye and curving back and down toward the anterior end of the maxillary denticles.

Fins: The vertical fins are not very high, and are concentrated at the far posterior end of the body. All are covered thickly with the dark body pigment. The dorsal and anal originate at the same vertical but, although the dorsal contains the greater number of rays, twenty-one, the anal is considerably the longer. Measured from the midline base of the caudal, the dorsal ends at a distance of 5 mm. and the anal of 9 mm. The caudal is small, deeply crescent-shaped, with the inferior lobe much prolonged.

The pectorals are placed very low and close together. They are short, wholly without natatory power, but greatly specialized as luminous organs. There are five rays, the 1st and 5th very long, thread-like and brown in color. The 2nd, 3rd and 4th show the same thin line of brown pigment but extending along their full length is a thick column of white, opaque, luminous tissue. The 1st, 2nd and 5th rays are equally long, 7 mm., but the remaining two are shorter.

The ventrals are pigmented, well-developed, consisting of seven rays, which however, are too filiform to be of much use in steering or progression.

A second specimen of *Lamprotoxus angulifer* was taken three weeks after the first; No. 22,483; Net 1187; August 17, 1931; twelve miles southeast of Nonsuch; 400 fathoms.

This fish is one-fourth as long as the first, but shows all the characteristics of the genus and species; standard length 33.6 mm.; head 5.7 (in length 5.9).

The fish was badly mutilated, the entire body cavity being torn open, but only the ventral photophores were injured beyond count; the fangs, the pectorals with their rays thickened with luminous tissue, the position and character of the ventrals. the long lateral line of luminous tissue along the side of the body, bent sharply downward close to the gill-opening, all confirm the validity of the species.

Discussion: This fish is close to *Grammatostomias dentatus* especially in number of pectoral rays, but differs decidedly in the much smaller eye relative to the head—5 in *Grammatosomias,* 9 in *L. angulifer* —and in the presence of the cephalic and somatic luminous patterns. This elaborate, lateral, light tissue is less developed in extent and wholly different in pattern, but directly related to that in *L. flagellibarba.*

Leptostomias bermudensis sp. nov.

Type: No. 20,826; *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1015; *June* 15, 1931; *7½ miles southeast of Nonsuch;* 500 *fathoms; standard length* 285 *mm.*

Measurements and Counts: Total length 297 mm.; standard length 285 mm.; depth 18 (in length 15.8); head 26 (in length 11.0); eye 4.3 (in head 6.0); snout 11.4 (in head 2.2); maxillary 15 (in head 1.7, in length 19.0); pectoral rays 12; pectoral length 12; ventral rays 7; ventral length 33; dorsal rays 20; anal rays 25; barbel length 200 (72% of length).

Teeth: In each half of the upper jaw are 5 teeth, the second largest, with several small subsidiary teeth. On the maxillary are 4 to 6 denticles, followed by a long line of very minute denticles. The dentition of the lower jaw, except for the absence of denticles, is similar to that of the upper.

Photophores: The photophores of the lateral series are arranged as follows: O-V 48, V-A 22; those of the ventral series: I-P 10, P-V 48, V-A 21, A-O 12.

Barbel: The stem is unbranched except at the very base of the bulb. It is black for a considerable portion of the proximal portion, then this pales and grays, and changes into brilliant lilac with a dark core running through it. The bulb is abruptly bright, clear, picric yellow. The filaments are translucent white with a scattering of black specks.

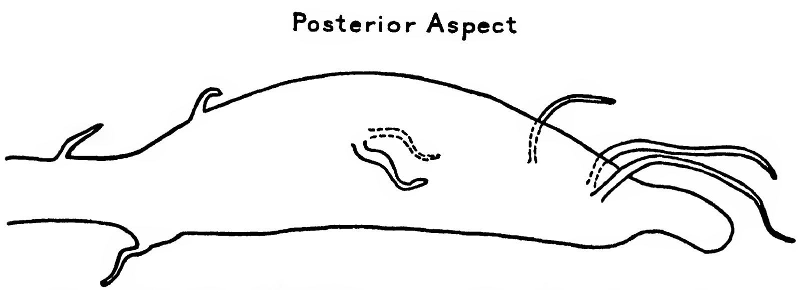


Fig. 10. *Leptostomias bermudensis* sp. nov. Barbel viewed from the left side.

The bulb arises abruptly from the stem, the lilac and the dark center ceasing at once. The bulb is slender, slightly curved, tapers gently from its center, and resembles in shape a diminutive cucumber. It narrows abruptly near the distal end, forming an elongate, rounded, terminal stem.

There are three short, thin median filaments given off, one from the back of the stem, and the other two from the proximal part of the bulb. Half-way down the bulb a pair of larger filaments arises, one from each side. Still farther a single one appears from the right side and, at the point of narrowing into the terminal stem, arises a final pair of filaments, the longest of all, about 4 mm. in length.

Discussion: This species closely resembles *L. macropogon* Norman and *L. longibarba,* Regan and Trewavas, but it may be distinguished from both by the structure of the bulb of the barbel and by the presence of 48 P-V photophores in both the lateral and ventral series.

Photichthys nonsuchae sp. nov.

Type: No. 9973, Bermuda Oceanographic Expedition, New York Zoological Society; Net 63; May 3, 1929; 7 miles south-south-west of Nonsuch; 600 fathoms; Standard length 89 mm.

Measurements and Counts: Standard length 89; depth 18 (in length 4.9); head 26.5 (in length 3.3); eye 8 (in head 3.3); interorbital 4.5 (in head 5.9); snout 6.5 (in head 4.1); mandible 18.5 (in head 1.4, in length 4.8); least caudal depth 7.5 (in length 11.9); pectoral 9; ventral 7; dorsal 12; anal 14; gill-rakers 5 + 13 (all, except 4 moderately long ones at the angle of the arch, are very short).

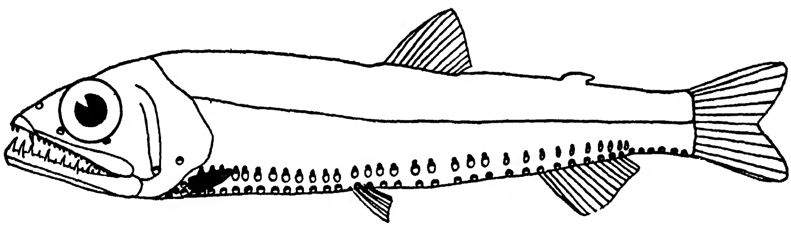


Fig. 11. *Photichthys nonsuchae* sp. nov.

Teeth: There are three pairs of teeth in the premaxillary: two small teeth at each side of the tip followed after an interval by a moderately strong canine. On the maxillary is a single series of about 16 pairs of small teeth with minute denticles between. In the mandible are ten pairs of large teeth with one or more smaller teeth usually present in each of the interspaces. The rudiments of a pair of teeth are barely distinguishable on the vomer. On the palatine are eleven pairs of curved teeth in a single series, decreasing in size posteriorly.

Photophores: There are 14 pairs of branchiostegal photophores. The lateral series of the trunk photophores shows the following arrangement, O-V 12, V- end of series 19. The last lateral photophore is located above the base of the last anal ray. The photophores of the ventral series are distributed as follows: Pre-pectoral 11, P-V 14, V-A 12, A-C 12.

Scales and Skin: All of the scales and most of the skin have been torn away.

Discussion: *P. nonsuchae* agrees with the generic description of *Photichthys* except in the following points: the vomerine teeth are

Fig 12 *Saccopharynx harrisoni* sp nov.

extremely rudimentary instead of well-developed and there are but 14 rays in the anal instead of 23 to 26. It differs from *P. argenteus,* the only species previously described, in its greater depth, longer head, larger eye, narrower interorbital width, longer snout, and fewer photophores. Comparative measurements illustrating these differences are as follows:

	P. nonsuchae	*P. argenteus* (according to Günther, Brauer, and Norman)
Depth in length	4.9	5.8 to 6.5
Least caudal depth in length	11.9	16.5 to 21.3
Head in length	3.3	3.8 to 4.8
Eye in head	3.3	4.0 to 5.0
Interorbital in head	5.9	5.0
Snout in head	4.1	5.0 to 5.1
Gill-rakers	5 + 13	5 + 11
Brr. photophores	14	21
Ventral photophores:		
V-A	12	15 to 17
A-C	12	16 to 18
Lateral photophores:		
Entire series	31	33 to 34
Position of last photophore	Above 14th anal ray	Above 6th to 10th anal ray

Saccopharynx harrisoni sp. nov.

Type: No. 20,802 *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1010; *June* 11, 1931; *ten miles Southeast of Nonsuch, Bermuda;* 900 *fathoms; total length* 1400 *mm. or* 55 *inches.*

Field Characters: A large-mouthed, extremely elongate, eel-like, black fish; teeth numerous and moderate in size; eyes and pectoral fins present; an elaborate and highly colored, laterally-flattened, luminous organ near the tip of the tail.

Measurements and Counts: Length (total and standard) 1400 mm. (55 inches); head and body 375 mm. (15.7 inches); tail 1025 mm. (39.3 inches); depth, just behind distended stomach 22 mm. (in length 63.6); depth 260 mm. from tail tip, 3 mm.; head to gill openings 113 (in length 12.3); eye 7 (in head 16); snout 12 (in head 9.4); maxillary 85 (in head 1.3); pectoral rays 33; pectoral length 15 mm.

General Description: The general body shape is that of an elongate black sausage, due to a large sized fish which was still undigested in

the stomach; the head, in profile, shows a slight convexity over the crown, and rises slightly to the tip of the snout; this is sharp and the profile of both jaws is a strong curve; the mandible is slender and curves up, shutting closely against the upper jaw. The eye is well-developed and has undoubted vision; the nostrils are large, half-way between the eye and snout, and close together. The anterior is slightly the larger, and each is surrounded by a raised, rounded rim. The gill opening is in the form of a long, narrow slit, 20 mm. in length, beginning at mid-pectoral, between them, and extending far forward.

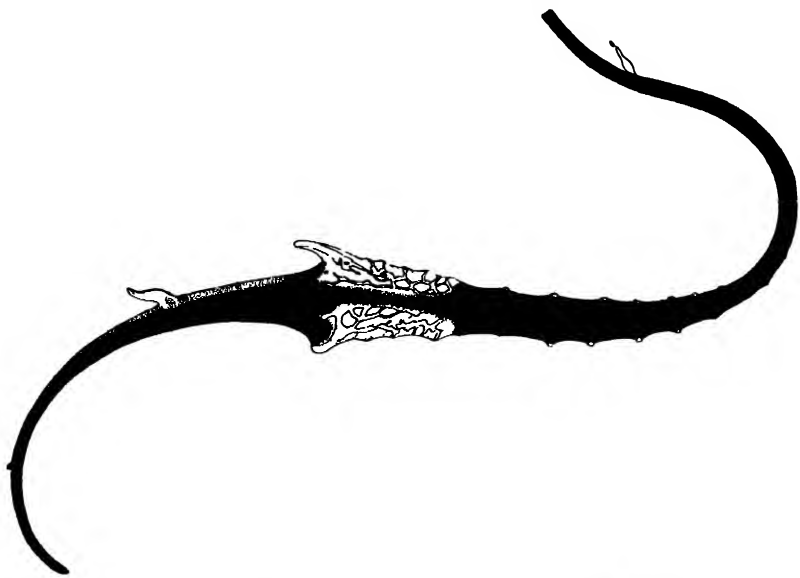


Fig 13 *Saccopharynx harrisoni* sp nov Luminous caudal organ

Teeth: There are 38 teeth in each half upper jaw, in two irregular rows, those in the outer row much smaller. In each half lower jaw are 30 teeth, in a single row, a large and a small tooth alternating with perfect regularity; the mandibular teeth do not reach very far back and disappear well behind the narrow, upturned symphysis. All the teeth are smooth-edged, but the sides show many irregular striae. The base of each is oval, arising abruptly from a slightly larger, flat, oval sub-base. Some are curved and fang-like, others straight, and they are set rather loosely in the jaws. The largest is 2.5 mm. long.

The skin of the top of the head, the anterior cheeks and around

the maxillary is smooth; all the rest of the skin of head, body, and tail is furrowed with a multitude of longitudinal and criss-cross wrinkles. The fish is jet black except for the specialized, luminous tissue near the tail tip, which is pink, deepening to blood red and dark purple around the base.

The dorsal fin begins far back on the body, just in front of the perpendicular of the anus—the latter opening occurring at about the 12th ray. The anal fin begins 20 mm. behind the anus. The dorsal rays are slightly larger than those of the anal, all are webbed and both fins die out about 200 mm. from the tail tip. The pectorals are paddle-like, with a thick, fleshy, basal pad, and a band of short rays around the free circumference. These are 33 in number and average 3.5 mm. in length. The pad is 10 by 15 mm.

Skin Glands: A few small tentacles are scattered along the lips and on the head,—and on the sides of the tail, from near its base to more than halfway to the tip, similar small tentacles are arranged at equal and frequent distances. At first they are often in pairs but farther along they occur singly, opposite one another, on the midline, about 10 mm. apart. These are not luminescent.

Luminous Structures: On top of the head, 45 mm. back of the snout, a curious structure arises and extends the entire length of the body to within 500 mm. of the tail tip. It consists of two deep troughs, sunk somewhat below the level of the skin and made considerably deeper by rounded, raised rims. Along the back these are very close together, separated by a septum only as wide as the exterior bounding rims. Toward the beginning of the tail these troughs separate and when the dorsal fin begins between them, they are well apart. Half-way down the tail they are 7 mm. apart. Each trough is filled with a bluish white luminous substance. When the fish was taken into the darkroom on its first arrival, a very distinct pale glow was visible along the back, but nothing whatever further back. The dorsal fin rays are each accompanied by a pair of scars or oblique slashes, each of which also contains the whitish substance.

Beginning some distance from the tip of the tail (150 mm.) is a succession of most remarkable structures, positively luminous as I found in the darkroom just before, or at the moment of death of the fish. The first, which is a considerable distance beyond the last finray, is a single pink tentacle, an elongate spindle with a tiny bead at the

tip, arising from the ventral profile. At this point the fish attains its shallowest depth, the tail here being compressed and only 2 mm. deep. For some distance farther the tail is smooth, then, 60 mm. from the tentacle, it begins to broaden and from the dorsal and ventral edges arise thirteen scarlet papillae, on the summit of low mounds almost devoid of black pigment. There are six on the dorsal and seven on the ventral profile. The small mounds are three to four of their base-lengths apart, not symmetrically placed with regard to those of the opposite side.

At an equal distance beyond these begins a most amazing luminous organ, a leaf-like, compressed, almost transparent zone, traversed with a network of large blood vessels. Posteriorly the dorsal and ventral tips are prolonged into exaggerated, finger-like imitations of the preceding papillae. These are scarlet pigmented, not pink with the blood like the rest of the organ. A central longitudinal band of scarlet-dotted, purplish black divides the organ into two. The dorsal finger is much the longer and freer, and there are two more of these dorsal structures trisecting the remainder of the tail. Beyond the leaf organ the tail rapidly diminishes in size, and shows considerable scarlet and purple arranged along both profiles, the scarlet dominant from the last finger-papilla to the tip.

The fish was caught by its teeth in the very collar of the net at the ring, and was saved from swimming away only by being jerked back as the net reached the surface,—a hint probably of how many of the larger fish escape. It was alive and fairly active, opening and closing its jaws, wriggling its body feebly and ejecting a large, half-digested fish. It died just as it reached the laboratory and when we were examining it in the darkroom.

In addition to the faint, colorless glow from the nuchal troughs, we distinctly saw a faint pinkish glow and twice a flash from the specialized caudal organ, and also from several of the scarlet papillae. Under the lens I could later see blood corpuscles moving very slowly along the exposed veins.

Part of the end of the intestine was everted at the anus and I drew out a considerable section together with a second ten-inch digested fish. The stomach had rather thick walls, and numerous longitudinal glandular ridges, the entire mucus lining being wrinkled with very fine, meandering lines and creases.

I have named this fish in honor of Harrison Williams, Esq., through whose continued interest and support these Bermuda Oceanographic Expeditions have been made possible.

Lampanyctus polyphotis sp. nov.

Type: *No.* 10,151, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 124; *May* 25, 1929; 5 *miles south of Nonsuch;* 900 *fathoms; Standard length* 40 *mm.*

Measurements and Counts: Total length 49; standard length 40; depth 8.2 (in length 4.9).; head 12.6 (in length 3.2); eye 3.9 (in head 3.2) snout 2.2 (in head 5.7); mandible 8.6 (in head 1.5, in length 4.7);

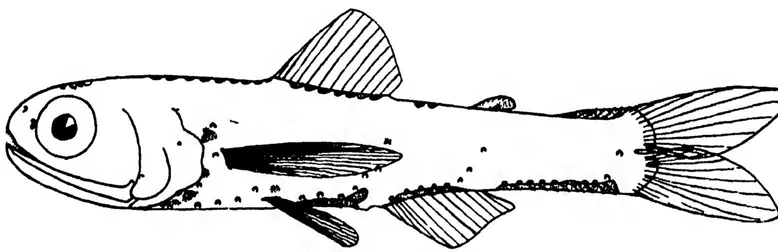


Fig 14 *Lampanyctus polyphotis* sp. nov.

pectoral 14; ventral 8, origin immediately under that of dorsal; dorsal 13½; anal 14, origin slightly in advance of end of base of dorsal; about 36 scales in the lateral line.

Photophores: PLO slightly below lateral line; 2 PVO in an oblique line, the upper in front of the upper pectoral rays, the lower entirely below the pectoral fin, above the second PO. 5 PO's, the fifth elevated. VLO nearer to base of ventral fin than to lateral line. 5 VO, the first lowered, the fifth elevated. 3 SAO in a broadly angulate series, with the uppermost photophore touching the lateral line and the lower above and slightly behind the fifth VO. AO's 6 + 6. The posterior part of the anal series is entirely behind the base of the anal fin. 2 POL, the upper in contact with the lateral line. 4 PRC, the distance between the first and third about equal to that between the third and fourth. Fourth PRC in contact with lateral line above and slightly behind the third.

Luminous patches and plates: There are 6 small patches arranged

in a circle on the top of the head. In front of the dorsal fin is a single median row of 9 luminous plates, none overlapping. Along the right side of the dorsal are found 8 plates, slightly imbricated, while there are but 7 on the left. About midway between the end of the dorsal and the origin of the adipose are two unpaired plates. There are 7 supra-caudal plates. On the ventral half of the body luminous plates are arranged as follows: There are five plates of various shapes and sizes on each side of the throat, below and in advance of the upper PVO. A similar one is placed above the base of the pectoral fin, while there is a very small patch above the base of the ventral fin. Along the ventral mid-line between the ventrals and the anus are four imbricated plates. Continuous with these is a single pair, consisting of one plate on each side elevated to border the anus. 6 plates, as closely imbricated as those of the caudal series, are found on each side of the anal base. The 12 infra-caudal plates occupy almost the entire space between the end of the anal and the base of the caudal fins.

Discussion: This species seems to be about midway between *Lampanyctus townsendi* (Eigenmann & Eigenmann) of the Atlantic and Indian Oceans and *Lampanyctus maderensis* (Lowe) of the Mediterranean. It may be distinguished immediately from both by the combination of a median series of plates in front of the dorsal fin (characteristic of *L. maderensis*) with a mid-ventral series of plates, exactly similar to those of *L. townsendi,* between the ventrals and the origin of the anal fin.

Lampanyctus septilucis sp. nov.

Type: *No.* 14,292a; *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 250; *July* 4, 1929; *7 miles south-southwest of Nonsuch;* 700 *fathoms; Standard length* 26.8 *mm.*

Measurements and Counts: Total length 32 mm.; standard length 26.8 mm.; depth 4.7 (in length 5.7 or 17.5%); head 8.0 (in length 3.4 or 30%); eye 1.4 (in head 5.7 or 17.5%, in length 19.2 or 5.2%) snout 1.3 (in head 6.2 or 16.2%, in length 20.6 or 4.8%); maxillary 5.9 (in head 1.4 or 74%, in length 4.5 or 22%); caudal peduncle length 6.0; least caudal peduncle depth 2.4 (in caudal peduncle length 2.5 or 40%, in standard length 11.2 or 9%); distance from snout to dorsal 12.0 (in length 2.2 or 45%); distance from snout to adipose 20.3 (in length

1.3 or 76%); distance from snout to base of ventral 11.2 (in length 2.4 or 42%); distance from snout to anal origin 15.3 (in length 1.8 or 57%); pectoral 15; ventral 8, origin under in front of dorsal; dorsal 12; anal 18½, origin under next to last dorsal ray; about 39 scales in lateral line; 5-13 gill-rakers.

Photophores: 1 minute preorbital photophore between eye and lower part of nostril. 3 or 4 very small post-orbital photophores. 1 shoulder photophore slightly anterior to the most dorsal part of the opercular margin. PLO close to lateral line. Upper PVO opposite upper pectoral rays. Lower PVO somewhat behind upper PVO. 5 PO's, the fourth elevated to the height of the upper pectoral rays.

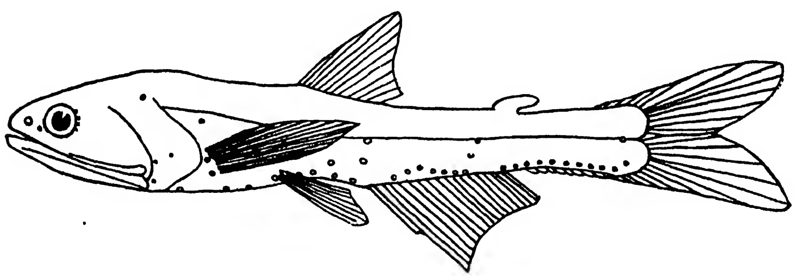


Fig. 15. *Lampanyctus septilucis* sp. nov.

VLO above ventral fin, nearer to lateral line than base of fin. 4 VO's, the second almost imperceptibly elevated. 3 SAO's, strongly angulate, the first slightly in front of the third VO. 7 anterior AO's on the left side, 6 on the right; the second, third, fourth and fifth elevated. 8 posterior AO's on the left side, 9 on the right; the first above the last and second from last anal rays respectively. 2 POL'S, the upper in contact with the lateral line. 4 PRC's, not distinct from posterior AO's; the distance between the third and fourth is about equal to that between the first and third; the fourth is in the lateral line slightly in front of the third. 3 supra-caudal, 9 infra-caudal luminous scales.

Comparison: A second specimen, 14,292b, standard length 27.6 mm., was taken in the same net with the type; and a third, No. 14,061, standard length 29.1 mm., in net 511 on September 27, 1929, thirteen miles south-east of Nonsuch in 700 fathoms. Neither differs perceptibly from the type either in proportions or arrangement of photo-

phores except in the following points: In the second specimen only one small, indistinct, post-orbital photophore is visible instead of the three or four comparatively distinct ones found in the type and in the third specimen. In both the second and third specimens there are seven anterior and eight posterior AO's on each side, instead of the asymmetrical arrangement found in the type. In the third specimen all of the anterior AO's are in a straight line, instead of the second, third, fourth and fifth photophores of the series being elevated.

Discussion: This species is most closely related to *Lampanyctus macropterus* Brauer of the Atlantic, Pacific and Indian Oceans, though it combines certain of the characteristics of *Lampanyctus omostigma* Gilbert 1908 from the tropical Pacific, *Lampanyctus omostigma parvicauda* Parr, 1931 from the western coast of Central America and *Lampanyctus nobilis* Taaning 1928 from the North Atlantic and Pacific. All are set off from the rest of the species of *Lampanyctus* by the combination of long and well-developed pectoral fins, a single luminous organ on each shoulder, but none on the cheeks, the elevated fourth PO, and the confinement of the luminous scales to the caudal peduncle. However, the present species may easily be distinguished from the other four forms by the following points: The VO's are in an almost straight line with the second barely perceptibly if at all raised, instead of having the second noticeably elevated. There are seven anterior AO's (except on the right side of the type specimen), instead of from four to six. The fourth PRC is located in the lateral line slightly in advance of the third, instead of behind it. Finally, the new species has fifteen pectoral rays instead of thirteen.

The following table is a comparison of the fins, number of scales in the lateral line, and the photophores of the new species with those of *Lampanyctus macropterus* and *Lampanyctus omostigma omostigma:*

	L. septilucis (*type*)	*L. macropterus* of Brauer and Parr	*L. omostigma*
Dorsal	12	12 to 14	14
Anal	18½	18 to 19	18
Origin of anal	Under next to last dorsal ray	Under middle of dorsal	Under next to last dorsal ray
Pectoral	15	13	13
Ventral	8	8	9
Lateral line scales	about 39	35	39

Photophores

Postorbital	3 or 4, very small	None mentioned.	None mentioned.
Preorbital	As in *L. macropterus* and *L. omostigma*	1 minute photophore between eye and lower part of nostril.	
Shoulder	As in *L. macropterus* and *L. omostigma.*	1 between upper part of praeoperculum and operculum.	
PLO	As in *L. macropterus.*	Close to lat. line.	2/3 as far from lat. line as from pectoral base.
PVO-upper	As in *L. omostigma.*	Opposite middle pectoral rays.	Opposite upper pectoral rays.
PVO-lower	As in *L. macropterus.*	Somewhat behind upper PVO.	Almost directly beneath upper PVO.
PO's	As in *L. macropterus.*	5. 4th elevated to height of upper pectoral rays.	5. 4th elevated to height of lower middle pectoral rays.
VLO	As in *L. macropterus* and *L. omostigma.*	Above ventral fin, nearer to lateral line than base of fin.	
VO's	4. 2nd scarcely elevated.	4. 2nd well elevated.	4. 2nd well elevated and above or slightly in advance of 1st. 3rd also elevated.
SAO's	As in *L. macropterus* (1st SAO in front of 3rd VO as in Brauer)	3. Strongly angulate. 1st slightly before or behind 3rd VO.	3. Not so sharply angulate. 1st behind 3rd VO.
AO's-anterior	7 on left side, 6 on right. 2nd, 3rd, 4th and 5th slightly elevated.	4 to 6. 2nd, 3rd, and 4th elevated.	5. 2nd, 3rd, and 4th elevated.
AO's-posterior	8 on left side, 9 on right. 1st above last and 2nd from last anal ray respectively.	8 to 10. First above next to last or 2nd from last anal ray.	8 or 9. First above 2nd from last anal ray.
POL's	As in *L. macropterus* and *L. omostigma* (except that upper organ barely touches lateral line).	2. Upper in contact with lateral line. (Gilbert counts lower POL as the 6th anterior AO).	
PRC's	4. Continuous with posterior AO's. 4th in lateral line slightly in advance of 3rd.	4. Distinct from posterior AO's. 4th in contact with lateral line, slightly behind 3rd.	4. Continuous with posterior AO's Arranged as in *L. macropterus.*
Luminous Scales			
Supra-caudal	3	3 to 4	4
Infra-caudal	9	5 to 10	9

Omosudis lowi
(Post-larva)

Post-larva Number 22,904, *Bermuda Oceanographic Expedition, New York Zoological Society; KOH Cleared Collection No.* 998; *Net* 1245: *August* 31, 1931; *eight miles south-east of Nonsuch;* 1000 *fathoms; standard length* 10 *mm.*

Measurements and Counts: Total length 11.45 mm; standard length 10 mm; depth 2.1 (in length 4.8); head 3.5 (in length 2.88); eye .86 (in head 4); snout 1.3 (in head 2.7); maxillary 2.4 (in head 1.45); pectoral rays .86; pectoral fleshy base .6; anal fin 14 rays; caudal 10 + 9; longest fang .54 mm.

General Description: This young post-larva is white throughout, with a sparse scattering of black dots; a few along the operculars and on top of the brain, and about a dozen down each side of the back, a third the length of the body; a squarish dark saddle on the back in the

center of the highest part of the dorsal fin-fold and just in front of the vertical of the front of the anal; six black dots along the ventral outline in front of the anal. All the fins are hyaline, except the pectoral which is quite dusky. The iris is solid silver, the spicules vertical.

The round protuberant stomach is dusky with thickly clustered,

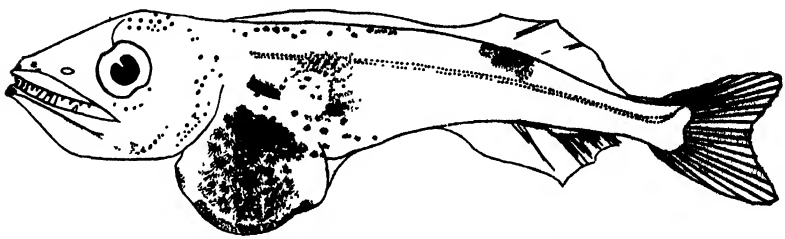


Fig. 16. *Omosudis lowi.* Post-larva of 6.58 mm.

very large dendritic chromatophores, while on top they form a solid black patch. This stomach contained a white, post-larval Myctophid of the same length (10.2 mm) as the *Omosudis.*

Dyed and Cleared: The osteological development at this stage is very interesting. There is not a particle of bone in the entire body,

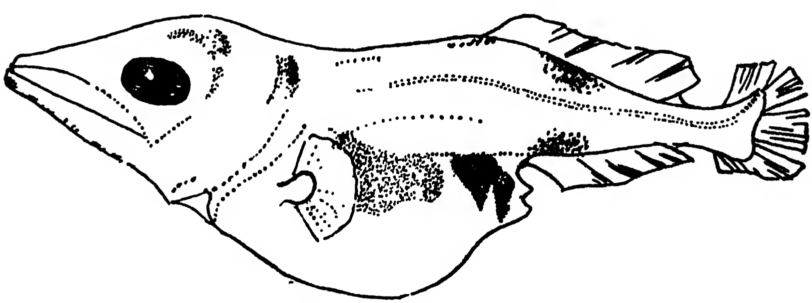


Fig. 17. *Omosudis lowi.* Post-larva of 10 mm.

fins, fin rays or appendicular skeleton, except for a faint trace in the center of the supracleithrum.

The head is set sharply off as a series of elongate, bracing bones, strongly ossified, and forming a nearly perfect equilateral triangle, the corners being the posterior borders of the frontals, the snout and the quadrate.

The entire top of the head is covered with the thin but well-ossified frontals, broad and rounded behind, and narrowing as they extend forward, until their needle tips actually touch the lateral, flaring, wing-like, superior edge of the still unjoined premaxillaries; a strongly ossified, buttressed ridge begins at the postero-lateral rim of the frontals where it shows two branches at right angles, and extends down the entire length of these bones. Its upper edge is looped from one body brace to another as far as mid-eye, and crenulated after that. The parietals show only as small oval, faintly pink cartilage; the sphenotics are better ossified and show a low, sharp spine; only the basal condyle of the opercular is ossified, the remainder being clearly outlined in cartilage; the hyomandibular is ossified only on the anterior edges; the preopercle is strongly ossified, beginning as a needlepoint in front of the opercular condyle and extending clear to the quadrate, slightly bowed, flaring in the posterior lower half into a broad, looped, bony web between strong spines.

The premaxillaries are not united at the symphysis; they extend back as the slenderest needles of bone, three-fourths of the way to the quadrate, with teeth all the way; there are fifteen altogether, the 1st, 3rd, 5th and 7th larger than the rest, the 5th a depressible fang of large size; the edentulous maxillary is a veritable thread of bone, well ossified, and flattening out toward its distal end; the palatine is stronger even than the premaxillary, arising at the vertical of the 5th tooth on the premaxillary, and extending back to beyond the vertical of the mid-eye; it bears five teeth longer than most of those in the upper jaw; posteriorly the palatine is overlapped by the slender spindle of the mesopterygoid, and this by the larger pterygoid.

The dentary is as strongly ossified as the premaxillary, and its two posterior forks reach almost to the quadrate; in the extreme front are two moderate-sized teeth, followed after a space by very tiny teeth; half-way down the jaw is a single enormous fang, with an auxiliary tooth of equal size just behind but lying flat, and ossified at the tip; halfway between this and the posterior tip of the upper prong is a single very small tooth, making five in all; the articular is thoroughly ossified only along the lower margin, and merges very closely with the angular; the quadrate, like the opercular, is surprisingly cartilaginous, and only its

condyle and the adjoining area are ossified. The basisphenoid is a strong rod and completes the tale of visible bones in this post-larva.

Post-larva Number 23,073, Bermuda Oceanographic Expedition New York Zoological Society; Net 1258; September 3, 1931; eight miles south-east of Nonsuch; 900 fathoms; standard length 6.58 mm.

Ossification much the same as in the 10 millimeter specimen, with a diminution in the development of the head bones such as might be expected in a fish one-third less in length. This individual had swallowed a squid quite as large and slightly longer than itself.

Melanonus unipennis sp. nov.

Type: No. 22,397, Bermuda Oceanographic Expedition, New York Zoological Society; Net 1182; August 15, 1931; ten miles south-east of Nonsuch; 700 fathoms; standard length 62.5 mm.

Measurements and Counts: Total length 70 mm.; standard length 62.5 mm.; depth 10 (in length 6.25); head 13.5 (in length 4.6) eye 2.8 (in head 4.8); snout 5.2 (in head 2.6); maxillary 8.2 (in head 1.6); interorbital 5.5 (in head 2.46); pectoral 16; pectoral length 8; ventral 7; ventral length 6.4; dorsal 100 (72 + 28); anal 79 (56 + 23); caudal 6; caudal length 7.5; scales 112; branchiostegals 7. Teeth in upper jaw, very numerous, small and in several rows, a few slightly enlarged canines in front; mandibular teeth fewer and larger, in two irregular rows, the inner row much larger than the outer.

Comparison: All the fifty-odd specimens of *Melanonus* which have been taken at our station show a united dorsal fin. There is no sign of division into two, between the first six to eight and all the remaining rays. Comparison must be made with *M. zugmayeri* of Norman as he distinguishes it from the type and other specimens of *M. gracilis* as the only one occurring in the North Atlantic.

The depth of my specimen is much less than that of *zugmayeri* (6.25, not 4.9); the head is smaller (4.6, not 4); the snout is longer (2.6, not 3.5); the dorsal fin is slightly larger (72, not 70) and the anal still more so (56, not 50); the posterior rays of the so-called third dorsal, second anal and caudal are more numerous in my specimen (57, not 50); the pectoral has more rays (16, not 13); and the lateral row of scales is fifteen percent greater in *unipennis* (112, not 80).

Pseudoscopelus stellatus sp. nov.

Type: *No.* 21,155, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1058; *July* 7, 1931; *eight miles southeast of Nonsuch;* 300 *fathoms; standard length* 23 *mm.*

Field Characters: A small elongate dark-skinned fish, with scattered iridescence, especially strong on the opercles, and a circle of successive rings of brilliant colors on the side, behind the pectoral fin. Double dorsal and elongate anal. Lines of small green chromatophores along the ventral surface from the isthmus to the caudal, small clusters on the mid-mandible, on the lower part of the preopercle, and at the base of the pectoral.

Measurements and Counts: Total length 26.5 mm; standard length 23; depth 4.5 (5.1); head 7.1 (3.2); eye 1.8 (3.9); snout 1.7 (4.2); maxillary 4 (1.8); interorbital 1.8 (3.9); dorsal VII-26; anal 26; pectoral 14; pectoral length 8; ventral 5; ventral length 4.3 mm.

General Color: Purplish brown, with tinge of pink on head and base of caudal; black chromatophores thickly scattered over most of the fish, while on the head and at base of caudal these are mixed with numerous flame-scarlet dots, most conspicuous on upper and lower jaws and in the anterior part of the isthmus. Mouth pale, speckled with black and scarlet inside. Proximal half of dorsal, anal and caudal rays speckled with black, pectorals and ventrals at their bases only.

Iris: Steel blue with greenish reflections and a scattering of black chromatophores around the edge.

Iridescence: Covering much of the fish, but especially strong on the sides of the head and anterior sides; consists of fine spicules on the dermis, in some places well separated from the transparent epidermis which carries the dark chromatophores; peacock blue just behind opercles and in front of ventrals; green in front of pectorals. Behind pectorals, partly beneath the fin-rays and partly above them, a peculiar iridescent area, the general impression being of a large, oval, green, bronze and blue ocellus as large as the eye: center blackish, around which is a ring of gold, then bronzy green, then blue and finally an outer ring of bluish violet. This last color extends forward to the opercle, and backward in a gradually diminishing band between the lateral line and the ventrals as far as the anal fin. Ventrally, along the abdomen, this changes to a greenish-black sheen visible only in some

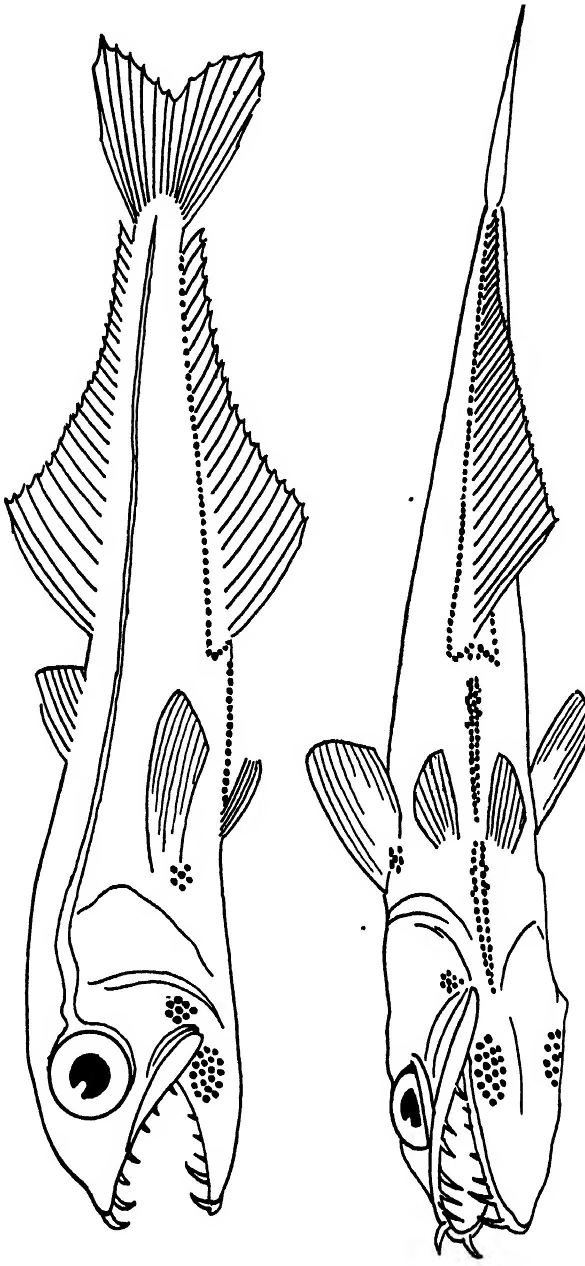


Fig. 18. *Pseudoscopelus stellatus* sp. nov.

lights. Preopercle is shining blue, opercle golden-green. The gills show through the branchiostegal membrane as bright pink.

The lateral line is a deep groove, bordered by a connected series of overlapping fleshy flaps. In life these meet across the lateral line, so that only occasional, separate openings are visible. When relaxed in death the two series of leaves or scallops spread apart and the trough is open throughout. In the fresh specimen a faint bluish iridescence is visible along the lateral line.

After death both body and fins become covered with a complete coat of thick mucus, which is replaced at least twice after being cleaned off.

Photophores: In the fresh fish the numerous photophores (354 altogether) are clear bright green—Night green of Ridgway. The organs are facetted as in those of *Cyclothone,* but from every angle show the same green, clear and intense. Within fifteen minutes after death the lights begin to fade to silvery white, those of the preopercle and mandible long before the ventral body lights.

Photophore Counts: Mandibular—19 in a compact, oval group on each side, beneath and in front of the posterior end of the maxillary.

Preopercular—8, in a small group at the lower tip of the triangle of this bone.

Base of Pectoral Fin—5 and 6, on the two sides respectively. Ventral Midline, Isthmus to Ventrals,—54, mostly in a double row, placed very close together, but with several irregularities.

Ventrals to Anus—47, beginning somewhat behind the ventral fins and ending well in front of the anus; usually in a double row, but irregularly single or triple especially in the extreme anterior and posterior portions.

Circum-anal—Right 89, left 90. This line completely surrounds the anal fin except for a slight break around the posterior end. The line is single except between the anus and the anterior beginning of the fin where it is irregularly double. These photophores are not equally spaced, nor are they all equal in size, and the slight gaps and congested areas do not correspond on right and left sides.

Pre-caudal—9, which are slightly larger than the circum-anal lights and are arranged in an unsymmetrical, roughly Y-shaped group, on the midventral line, just in front of the origin of the caudal fin.

Discussion: *Pseudoscopelus scriptus* was described in 1892 by Lütken (Spolia Atlantica (2) 1892, pp. 284-285) and since then redescribed and pictured by Goode and Bean (Oceanic Ichthyology, 1895, pp. 292-293, figure 266) and Norman (Annals and Magazine of Natural History, 1929, (10) Vol. III, pp. 543-544, figure 11).

Owing to the small size of the photophores and their ultimate superficial obscurance by mucus, all these authors have described them as mucus pores. Norman even omits them from his illustration. Goode and Bean depict them correctly but describe them as "series of closely placed pores" while Norman says in his caption "The rows of small pores on the head and body have been omitted."

Pseudoscopelus stellatus differs from Goode and Bean's description of *Pseudoscopelus scriptus* in various proportions; in having no cross-line of "pores," placed "immediately behind the ventral fins"; and the length of the pectoral fins is not "nearly three times as great" as the ventrals, but less than twice. The illustration shows a line of "pores" along the maxillary and two shorter lines along the mandible, while in *Pseudoscopelus stellatus* these are absent, there being two groups, one on the preopercle, and the other on the mandible. The group of photophores at the base of the pectoral in *Pseudoscopelus stellatus* is wholly lacking in Goode and Bean's illustration.

Norman states "diameter of eye 6, interorbital width nearly 3 in head," while the corresponding proportions in my fish are 3.9 in both cases.

The short rounded snout, the several rows of palatine teeth and the presence of "definite rows of small mucous pores" (= photophores) clearly sets this fish off from *Chiasmodon* and places it in *Pseudoscopelus,* but it very distinctly has the several pairs of anterior, large, recurved, canine fangs supposedly characteristic of the former genus.

Several young *Pseudoscopelus stellatus* have come up in shallow hauls.

No. 21,404, (2), Net 1084, July 15, 1931, are from a depth of twenty-five fathoms. This number includes two fish of 20 and 23 mm. respectively. Although the latter is quite as large as the type yet it is distinctly a larva. In general color both are pale pink with numerous black dots, strongest dorsally. There are strawberry-pink patches in the following positions, similar in both individuals: one at the base of the 1st dorsal, four along the 2nd dorsal, three along the anal, and five

on the midline of the body, distributed evenly from the vertical of the 1st dorsal origin to the base of the caudal. These bright pink spots are thickly peppered with small black chromatophores. The caudal is densely speckled with black.

The iris is silver, edged with black. The opercle shows a strong steel blue, golden and green iridescence. On the sides, and extending down almost to the abdomen is a conspicuous rainbow series of colors, adumbrating the ocellus of the adult. Here, however, it is an elongated, semi-ellipse instead of an oval, and extends from the top of the pectoral base almost to the anal fin. Deep violet ventrally, it ranges through bluish-violet and peacock blue to emerald green and gold.

In both these individuals there is a distinct trace of the ventral photophores, about four pairs between the ventrals and anal, and an equal number at mid-anal. There is also a hint of the cluster of photophores on the mid-mandible. These beginnings are in the form of distinct black centers to very large, dendritic chromatophores. There are also unusually large chromatophores between the anal and caudal, anticipating the irregular peduncular line of light organs. There are two rows of teeth on the palatines, and at the premaxillary symphysis are two pairs of large, sharply bent, backward pointing fangs.

A still younger individual of this species is No. 21,321 of Net No. 1069, hauled on July 10, 1931 from a depth of 50 fathoms. It is 14 mm. standard length, and in general color is white, with oblong, longitudinal patches of grenadine-red chromatophores placed as follows: three along the anal base, one under the anterior dorsal fin, three under the 2nd dorsal, and four along the mid-line between the base of the dorsal and the base of the caudal. The two posterior colored areas of both dorsal and anal fins are each overlaid with two, large, black pigment spots. There is a slight duskiness on the top of head and tip of snout. The fin-rays are white with an irregular sprinkling of black and reddish chromatophores.

The smallest *Pseudoscopelus stellatus* measures 10 mm. in standard length. It is No. 21,456, Net No. 1093, taken July 18, 1931, from 300 fathoms depth. It is translucent white with red spots, one at midbody on the midline and one each at the center of the 2nd dorsal and of the anal. The crown of the head has a group of small, round, black chromatophores. Iris silver, laid thinly over the black of the eyeball.

Fig. 19. ***Parabrotula dentiens*** **sp. nov. Jaws.**

The following table shows the relative changes in growth in three specimens:

Standard Length	*Head / Length*	*Eye / Head*	*Snout / Head*
10	3.7	3	2.7
20	3.3	4	3.5
23 (Type)	3.2	4	4.2

Parabrotula dentiens sp. nov.

Type: *No.* 15,882, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 692; *June* 12, 1930; *eight miles southeast of Nonsuch Island, Bermuda;* 800 *fathoms; standard length* 28 *mm.*

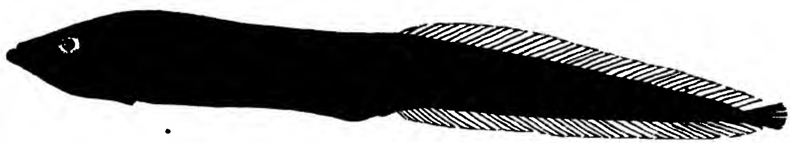


Fig. 20. *Parabiotula dentiens* sp. nov.

Field Characters: A small, black, scaleless, brotulid fish, with large oval eyes, projecting lower jaw, no ventrals, vertical fins beginning at mid-body and continuous with the longer rayed caudal.

Measurements and Counts: Standard length 28 mm.; total length 28.9 mm.; depth 2.7 (in length 10.3); head 4.8 (in length 5.8); eye .86 (in head 5.5); snout 1.5 (in head 3.2); maxillary 2.7 (in head 1.8); mouth angle 20° up; ocular angle 20° up; ocular divergence 25° forward; branchiostegals 6; vertebrae 59 (23 + 36); pectoral 7; pectoral length 1.2 (in head 4); dorsal 41; anal 39; caudal 6; caudal length .9 mm.

General Description: The color is jet black; the body is elongate, the head flattened above, sloping straight down from nape to snout; the eye is large, oblique, oval, covered by thin transparent skin; the gape reaches behind the eye, the lower jaw projecting in front.

The teeth are wholly lacking in the upper jaw, but there are twelve in the lower, small, far apart and bent sharply backward. The skin is thin and scaleless. The vertical fins are composed of soft cartilaginous jointed rays; the pectoral rays are soft and cartilaginous except at the base; the ventrals and the pelvic arch are wholly lacking.

Osteology, from the stained and cleared type: There are 59 vertebrae, 36 of which may be termed caudal. All are well ossified except the two posterior ones, which are cartilaginous, showing faintly, together with a solid caudal basal support, and a hint of urostyle. There is no apparent division between trunk and tail vertebrae except the position of the anus. The neural and haemal arches are well developed, long, and slant slightly backward, but there are no other appendages.

The basis cranii is the only part of the skull to show very evident ossification. The cleithrum and supracleithum are strongly ossified, as are the opercle and interopercle. The other elements are barely visible. The 1st branchiostegal has no visibly ossified point of attachment. From a very faint ceratohyal arise the 2nd and 5th backward curving branchiostegals and a 6th extends almost straight between the two better developed opercular bones. The quadrate is strong.

The premaxilla and maxilla are slender, almost rodlike, the latter ending far from the quadrate, and both are toothless. When any opening pressure is applied to the jaw, it is the upper which opens, the snout wrinkling above, giving along the posterior cartilage. The mandible is remarkably strong, both dentary and angular, and shows but slight downward movement. There are six, very small, widely separated, backwardly directed teeth on each ramus of the former, the first well away from the symphysis. Of the pectoral fin, only the bases and a fraction of the seven rays show any ossification. The dorsal, anal and caudal rays are soft and wholly lacking in bony tissue.

The oesophagus is large and distended, and there is little differentiation into stomach and intestine in the undissected fish.

Much of the body is filled with masses of small oil globules, especially behind the eye, and again behind the aural cavity, over the surface of the body organs, and a solid mass down the bases of the vertical fins, along the entire profile of the body.

Comparison of No. 15,882 with *Parabrotula plagiophthalmus*:

The appended table shows at a glance the difference between my specimen (No. 15,882) and the one described by Zugmayer.* The major distinctions are that my fish, while about the same length, has a much longer anal fin, a shorter pectoral, the body is more slender, the head and eye are smaller, the mouth larger, and there are teeth present.

**Zugmayer, Bull. Oceanogr. No.* 193. *Monaco,* 1911; *Zugmayer, Res. Camp. Scient. Albert First; Fas. XXXV,* 1911, *p.* 129, *Plate VI, fig.* 5.

Monaco's fish was taken at 1500 meters depth, 43° 4′ No. Lat., 19° 42′ West Longitude, about 480 miles north-east of the Azores.

	Parabrotula plagiophthalmus	*P. dentiens* No. 15,882
Standard length	24 mm.	28
Dorsal	40	41
Anal	30	39
Pectoral	7	7
P. length	2.3 mm.	4 mm.
Caudal	5	6
Depth in length	8	10.3
Head in length	4.5	5.8
Mouth in head	2.3	1.8
Maxillary	mid-eye	behind eye
Eye in head	4.3	5.5
Branchiostegals	5	6
Teeth	0	12 in mandible

Chaenophryne crossotus sp. nov.

Type: Number 20,809, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1015; *June* 15, 1931; *eight miles south-east of Nonsuch;* 500 *fathoms; standard length* 17 *mm.*

Measurements and Counts: Total length 20.7 mm.; standard length 17 mm.; depth 9.4 (in length 1.8); head 11.4 (in length 1.5); eye 1.5 (in head 7.6); snout 6.8 (in head 1.67); mandible 8.5 (in body 2); pectoral length 2.3; dorsal 7; anal 6; caudal length 3.7; illicium 5.7 (in head 3).

General Description: Outline typically chaenophrynine, strongly arched above, almost flat below, snout short and blunt, peduncle narrow and tapering into caudal; eye small, directed considerably forward; nostril openings at end of small tube near tip of snout; mouth large, almost horizontal, gape well behind eye: Teeth very small and few in number in upper jaw, about five on each ramus; ten on each half mandible, about half of them twice as large as the others, and three times as long as those in the maxillary; three pairs of vomerine teeth; the skin is velvety jet black as are all the fins; the anterior half of the lower lip is pale, fitting into the loose upper lip when the mouth is closed; no spines are visible; the rays of all the fins are encased in black skin, with the brushy tips white.

The illicium base bone is wholly concealed under the skin; the stem emerges close to the tip of the snout, black for half its length, and

becoming pale translucent white where it rises above the deep trough; it widens anteriorly into the large bulb, the posterior profile remaining straight; a brown inner core occupies about a third of the posterior aspect of the translucent stem, and flares quickly into the oval, blue-black bulb; at the upper end of the bulb there arises a pair of black spheres balanced side by side on the end of short stalks; immediately behind them is a small saddle-shaped black mark; at the postero-

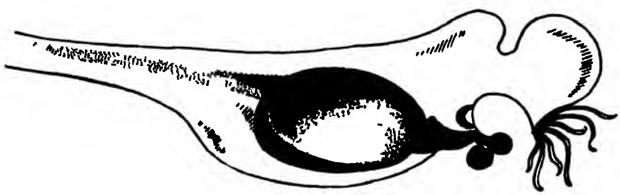


Fig. 21. *Chaenophryne crossotus* sp. nov.

superior edge of the illicium a broad high translucent, white crest arises, divided mid-way by a deep posterior notch and flaring out distally into a round comb, with an anterior point from which springs a tuft of seven, slender, thread-like white tentacles.

Chaenophryne draco sp. nov.

Type: 22,396, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1181, *August* 15, 1931; *ten miles south-east of Nonsuch;* 600 *fathoms; standard length* 18 *mm.*

Measurements and Counts: Total length 23 mm.; standard length 18 mm.; width 10 (in length 1.8); depth 9.7 (in length 1.85); head 12 (in length 1.5); eye .8 (in head 15); snout 4.5 (in head 2.6); maxillary 4.3 (in head 2.8); visible dorsal rays 4; visible anal rays 2; pectoral 18; pectoral length 2.1; caudal 9; caudal length 5; illicium length 6.4.

General Description: Snout rising from upper jaw almost vertically, then continuing into the long, even dorsal curve which straightens out gradually to the tail; the ventral outline is almost horizontal; eye rather small, just back of the gape, half-way between the gape and the dorsal outline; nostril on a low tubercle, close to tip of snout; mouth large, horizontal.

Teeth very small and few in number in the upper jaw, six in each

ramus; those of the lower jaw are two to three times as long, and nine to ten in each half jaw, four of these being long curved fangs; there are three pairs of vomerine teeth, strongly graduated, the smallest in front.

The skin is jet black, with a surface which looks like the nap of black velvet, except the lips which are smooth and dark brown; the fins are all black, only the illicium is different in color. There are no surface glands visible and spines are wholly lacking, although the infra-

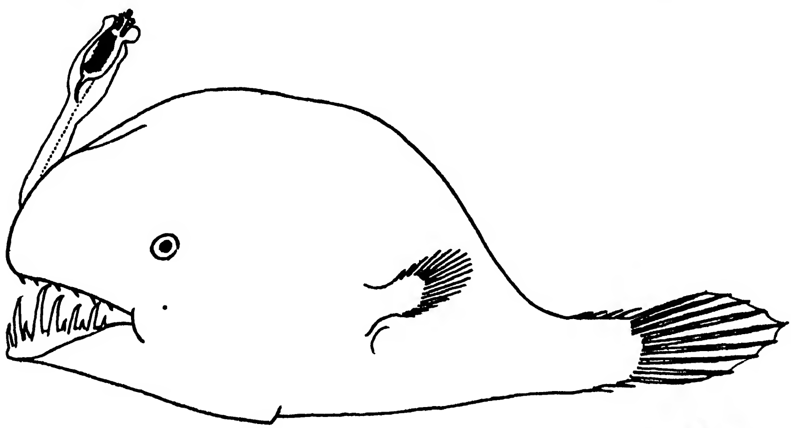
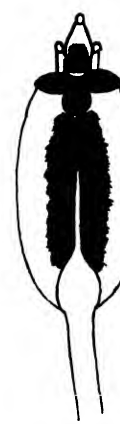


Fig. 22. *Chaenophryne draco* sp. nov. Illicium at right.



posterior mandible angle is clearly indicated through the skin. The rays of the ventral fins are low and inconspicuous and probably not all project through the outer skin; each is enclosed in a black sheath, but bare at the tip, like the rays of the pectoral and caudal.

The illicium is a very complex organ, but lacks elaborate tubercles. The basal bone arises half way between the vertical of the eyes and the snout, but is visible only from above and that for but a short portion of its length; posteriorly it disappears at once beneath the skin, although the outer skin itself is devoid of pigment for a short distance farther; it then sinks below the surface, leaving a deep, narrow, epidermal furrow which persists on the top of the skull, to a point well behind the eyes. From above, the anterior profile of the elbow of the basal bone and the illicium stem just reaches the vertical of the tip of the snout;

the stem is translucent, pale purplish blue, the terminal bulb convex anteriorly, the stem continuing straight up behind; at the anterior base of the bulb is a large, round pad of pinkish-white, silvery spicules, sending a long, narrow extension upward; beneath this is an ebony plaque, on each side of which the silvery spicules extend up from below, ending in an irregular edge on the black. Distally, where the line of spicules dies out, a new and complex structure begins; on mid-body is a rounded, black flap like the full-spread tail of a bird lined along the edge with silver, while from each side sprout two moderately elongate black wings, thickly mottled with brown; beyond there is a thick, tubular body, extending to the anterior tip of the illicium, black, graying gradually to white at the end; on each side near the base of this tube in advance of the wings and projecting back beneath them, are two smaller tubes of pale bluish, each ending in a plug of silvery spicules; beneath the median terminal, tubular body and separate from it, is a fin-like extension of the translucent, bluish-purple tissue, transverse like the fin of a squid.

Dolopichthys gladisfenae sp. nov.

Type: *No.* 15,490, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 639; *May* 28, 1930; *six miles south of Nonsuch Island, Bermuda;* 700 *fathoms; standard length* 40 *mm.*

Field Characters: A somewhat elongated Dolopichthid, articular spines absent, skin spiny, teeth few, dorsal 5, anal 5, illicium 4.7 in length, bulb structure complicated.

Measurements and Counts: Standard length 40 mm; total length 54 mm.; depth 16 (in length 2.5); head, to gill openings 20.7 (in length 1.9); eye 1.1 (in maxillary 4.5); snout 3.3 (in maxillary 1.5); maxillary 5 (in length 8); intersphenotic 7.1; mouth angle 30° up; ocular angle 15° up; ocular divergence 10° forward; pectoral length 3.8; dorsal 5; anal 5; caudal 9 (2+4+3); caudal length 14; illicium 8.5 (in length 4.7); basal bone 3.1 mm.

General Description: The fish is elongate and moderately deep; the back is parallel with the ventral outline, almost horizontal; the anterior profile shows a slight downward curve from sphenotic to snout; the head is elongate, somewhat flattened above and below; the interorbital to the snout is free of spines, longitudinally elevated, with a

deep groove down the center; the snout is round in profile, flattened above; the eye is small, the nostril is a thick, short tubercle, placed two-thirds of the distance from eye to illicium; the mouth is moderately large, terminal and oblique; the maxillary reaches the front of the eye.

The teeth consist of nine small, sharp, subequal pairs in the upper jaw, set in a deep, wide groove formed by the rounded lips on one side, and an inwardly stretched, dark, dermal velum within; there are twelve pairs of larger teeth, graduated in threes, in the lower jaw; three vomerine teeth are visible on each side, strongly graduated, the shortest toward the mid-line.

The skin is smooth on the illicium, lips and a wide area from behind the sphenotic spines forward to the mouth; everywhere else it is beset thickly with small spines, and a scattering of mucus glands in the form of short, stout tubercles (as in *Cryptosparas*); the articular spines are absent; the sphenotics are small and sharp, projecting less than 2 mm. above the surrounding surface, about half of the height free of skin; the dorsal and anal fins have low, separate rays, very broad at the base, tapering to an exposed, fine point, useless for swimming; the pectorals are short, thickset, of thirteen rays.

Illicium: The illicium arises from near the tip of the snout, directed low and obliquely forward. It is jet black to the first joint, the pigment then thinning out, only along the sides reaching the base of the bulb as a faint duskiness. Above and below, the stem becomes abruptly milky white. The core is dark and upon its tip is placed the bulb, rounded except on the bottom which is flattened and curved inward to the core. The bulb is jet black with the basal half covered with iridescent, glittering spicule scales, silver, green and bronze, arranged with their long axes concentrically. The top of the bulb is of pale, lemon yellow, luminescent material, with the center changing abruptly to bright yellow, and from each side of the base of this a triangle of the glittering scales extends down over the black area. Above the cap and close to it, there arise from the center three flat, horizontal, fan-shaped disks of the luminous yellow. All the structures thus far mentioned are included in the coating of translucent, milky tissue.

Viewed from above, the bulb shows its lower half and a thin line around the cap covered with the glittering scales, elsewhere jet black. In the center, the black of the bulb rises a little, and is capped by a tiny mound of the bright scales. Above this the protecting tissue

(which shows transparent in a downward view over the bulb) is drawn up into a point, tipped with three finger-like tubercles, turning white at the tips. Beneath there is a misty, pale green tissue, very delicate, looking like a puff of pale green smoke. The lemon cap is split down the center fore and aft, and the green mist disappears into the anterior part of this crevice, where it becomes a deeper emerald green. Suspended above this is an intricate, silvery scaled structure like a bird in flight—the head of the bird with three black dots, close behind the base of the green smoke, the silvery wings stretched wide on each side. The body above and behind is encased by the mass of tentacular matter—the large rounded, elongated, thick projection, with a similar, smaller one directly behind, both composed of delicate, cobwebby, frosted tissue. Halfway down the larger, many small isolated, pale pink tentacles appear (28 are visible at once from one angle), and these increase in number, complexity and length, and become deep pink, until the two terminal projections, the body and half the wings of the silver bird, are buried in a mist of pink. Posterially, behind and below the second protuberance, two long finger-like tentacles arise, widely separated from the grey covering tissue.

Dolopichthys tentaculatus sp. nov.

Type: *No.* 23,170, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1271; *September 7th,* 1931; *ten miles south-east of Nonsuch;* 600 *fathoms; standard length* 13.5 *mm.*

Measurements and Counts: Total length 19.5 mm.; standard length 13.5 mm.; depth 7 (in length 1.9); head 9.3 (in length 1.4); eye .86 (in head 18); snout 2.1 (in head 4.4); mandible 5.7 (in head 1.6); pectoral rays 18; pectoral length 2.4; dorsal 4; anal 4; caudal rays 9; caudal length 6; illicium basal bone 1.8; stem and bulb 2.8; dorsal illicium tentacle 4 mm.

Description: Body typically dolopichthine in shape, enormous, high-arched head and back, horizontal ventral surface; pectoral and caudal fins well-developed and functional; vertical fins with barely projecting tips, wholly useless; sphenotic and articular spines prominent; quadrate and mandibular spines small, the former slightly the larger. Basal bone of illicium arising halfway between eyes and tip of snout, extending well in front of snout and jaw.

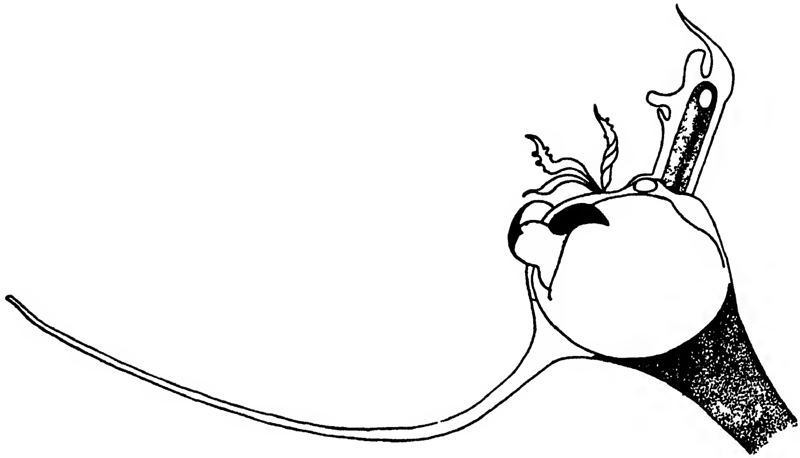


Fig. 23. *Dolopichthys tentaculatus* sp. nov.

Body, all fins, basal bone and proximal half of illicium stem dark seal brown; iris dark blue with a scattering of silver spicules; teeth transparent, colorless. The brown of the illicium stem includes about one-third of the bulb, the distal two-thirds being blue-black. From the dorsal side of the bulb (in its usual forward pointing position) arises, at right angles, a long, slender, pliable, colorless, translucent tentacle, tapering only slightly; from the opposite, ventral side of the bulb springs a rather stout, even-sided projection, pale brown except at the tip where it shows two, lateral, luminous facets. The whole structure is included in the translucent tissue, very thin along the brown part, but extending beyond the tip in two protuberances, one above the other, the upper a short, colorless tubercle, the lower a longer, upturned curved tentacle. From the upper part near the extremity of the brown tube arise two small, luminescent tubercles. There is a second pair of luminous facets on the bulb near the base of the tube.

Between the elongate dorsal tentacle and the ventral tube the blue-black of the bulb is split vertically, showing silvery tissue, and giving rise to several specialized organs. Near the base of the long tentacle there is a widening of the sub-silver, and this same tissue is raised above the level of the bulb into a thick, flat-topped comb, the summit of which is black; at the anterior base of this comb two large flat, triangular leaves of black tissue arise, and extend out, over and

above the surface of the bulb. Halfway between their bases and the tube-like, ventral luminous organ three, slender-stemmed, translucent, twisted leaves spring from a single base.

Mandibular teeth are very long and slender, the tips slightly incurved; there are thirteen in each half-jaw, graded in size by two's and three's; the teeth of the upper jaw are small and fewer in number, nine or ten on each side. Three good-sized teeth on vomer.

Comparison: This is closest to *Dolopichthys obtusus* the type of which is excellent for comparison for it is of exactly the same size. Among other dissimilarities each species has a different arrangement of structures on the illicium bulb and, curiously, the arrangement is reversed.

Linophryne arborifer Regan
(Post-larva)

Specimen No. 22,400, *Bermuda Oceanographic Expedition, New York Zoological Society; Net Number* 1182; *August* 15, 1931; *ten miles south-east of Nonsuch Island;* 700 *fathoms; standard length* 27 *mm.*

Field Characters: An oval fish; translucent, bluish white outer balloon skin; fins, lips and eye-sockets white; eye well-developed; teeth moderate; illicium bulb and mental barbel just through epidermis; sphenotic, quadrate and mandibular spines clearly visible; anus sinistral.

General Measurements and Counts: Total length 35.7 mm.; standard length 27 mm.; depth 18.8 (in length 1.4); depth, inner body 10 (in outer depth 1.8); head 15 (in length 1.8); eye 1.7 (in head 8.8); snout 4 (in head 3.75); maxillary 5.7 (in head 2.6); pectoral 14; pectoral length 2.8; dorsal 3; dorsal length, total 7.1, external length 21; anal 3, total length 7.1, external length 28; illicium stem and bulb 2.8; bulb diameter .8 mm.

General Description: External profile an almost regular oval, dorsal and ventral surfaces equally curved; snout drops almost vertically to lip; eye large, well-developed, the only black tissue about the fish, the eyeball bluish black, iris with silvery spicules, densest below, dying out on the outer half of the sides and the top; nostrils a little nearer apex of snout than eye, both openings very small and on the summit

of a long, thin narial stalk arising from the skull proper, at the same vertical as the illicium stem; mouth moderate, the gape reaching to mid-eye, slanting up 20 degrees.

Teeth: At the premaxillary symphysis there is a deep bay, the inner rim of which is lined with two teeth; along the outside are four or five very small, straight teeth; along each half jaw are 18 to 20 inwardly curved teeth, the anterior ones largest; some of these are arranged in double rows hinting of the several oblique lines in the adult, and five or six are obviously replacement teeth, each ready to take the place of its companion when it falls out.

The teeth in the lower jaw are very similar to those in the upper, except that there are only three anterior, small straight teeth, there is no symphysial bay, and the anterior three or four pairs of canines are larger than any in the upper jaw. The velum within the upper jaw is so wide that the roof of the mouth cannot be seen.

The outer skin is smooth and covered with an infinity of minute black dots which gives it a grey appearance. Along the sides of the head and body is a sparse scattering of numerous, small, dark, dendritic chromatophores, which die out gradually at the vertical of the eye and gape, the anus, and the dorsal and ventral outlines. They are thickest around the gill-openings. Of the internal body, the region of the eye, snout, post-brain, and whole vertebral body are unspotted white, with a few, large chromatophores on the side of the peduncle. The upper surface of the brain and the opercular region have many large chromatophores, and there is a black patch at the anterior base of the dorsal fin. The base of the coelom nearest the body is black, the ventral surface uncolored; the branchiostegals are clearly marked, dusky against a pale background. The sphenotic, quadrate and posterior mandibular spines are well developed but do not reach the surface of the outer epidermis. The internal vertebral body is of comparatively shallow depth, parallel-sided, with the bases of the vertical fins prominent, with oblique posterior faces. The dorsal and anal have three rays, only two-fifths of which project beyond the outer skin, an amount quite insufficient for any natatory or balancing use. They emerge close to the caudal. The caudal has eight rays, the two outer small and not reaching the full length of the tail.

The basal bone of the illicium is strong, arises from the supra-occipital and extends forward flat on the skull, giving rise, halfway

between the eyes and the snout, to a short, stout, vertical stem. This enlarges into an opaque, roundish bulb, about a quarter of which projects in a large dimple, above the outer skin. From the middle of the throat of the external skin, directly beneath the eye and the posterior end of the gape is an external bulbous swelling about the size of the illicium bulb. This has a notched cap over the summit, and it has no visible tissue connecting with the internal chin or jaw or head. It is unquestionably the anlage of the mental barbel.

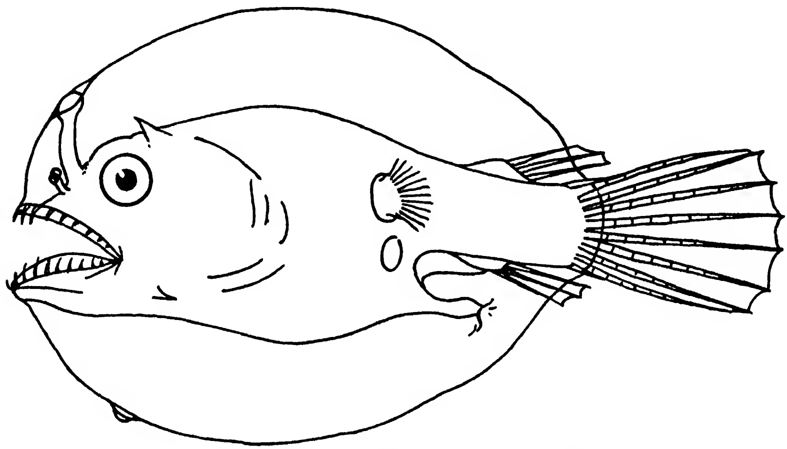


Fig. 24. *Linophryne arborifer* Regan. Post-larva.

Discussion: Owing to the balloon-like, inflated outer skin of this pediculate post-larva, the real fish within has direct contact with the outer world through only fourteen channels, mouth, two eyes, two nostrils, illicium, two gill-openings, anus, two pectorals, dorsal, anal and caudal fins. The remainder of the surface is more or less spongy or rubbery, almost transparent tissue, traversed only by a sparse network of white meandering nerves. The only actually normal sessile organ is the mouth which, as usual, is attached closely to the skull, with, of course, direct open contact with the water. The pneumatic outer skin meets at the lips, making the jaws and teeth usual in appearance. The adaptations of the other points of contact are as follows:

Eyes: In the normal position on the lateral aspect of the skull, but considerably beneath the external skin; contact is made by means of

an absolutely transparent pit, with flaring sides, roofed by thin invisible skin whose presence is revealed only by touch.

Nostrils: Both openings are close together on the summit of tall slender stalks.

Gill Openings: Small and round at the summit of hollow tubes.

Anus: Sinistral, at the end of a long, slender, intestinal tube.

Pectoral: Half of the fleshy base is subdermal.

Dorsal: Three-fifths of the ray lengths are subdermal.

Anal: Three-fifths of the ray lengths are subdermal.

Caudal: One-tenth of the ray lengths is subdermal.

Late Embryo: In net No. 287 there came in the egg of a ceratioid. This is Number 11,509, and was taken July 11, 1929, nine miles south-east of Nonsuch, at a depth of 700 fathoms.

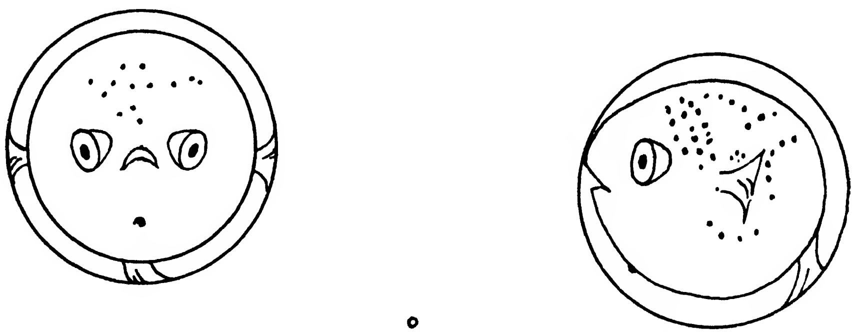


Fig. 25. ***Linophryne arborifer*** **Regan. Late embryo; natural size in center.**

The egg was round, 1.3 mm. in diameter and perfectly hyaline. It was almost filled with a fully-developed young ceratioid. The front view shows it in outline as round as the slightly larger egg, with two equally round eyes, directed well forward. It touches the inner wall of the egg shell at three points—the pectorals and caudal. The former are so big that they are bent over at the point of contact, and the tail fin is pushed downward and to one side, all braced hard against the little sphere. The lateral view shows in profile only two contacts—the snout pressed against the egg and the bent and depressed tail fin. I can detect no signs of vertical body fins. The inner, narrow body of the fish is translucent and the outer balloon skin is so thin and transparent that only in certain lights is it visible at all. Its general con-

tour on the head and sides is faintly indicated by a sparse scattering of pale blue chromatophores. There is no sign of an illicium, but the most significant character is a distinct dark spot, resolving into a slight elevation under high power, on the throat. A ceratioid with a mental barbel can be only a *Linophryne,* and so I choose to consider this as the earliest known stage of the only common species, *arborifer,* which we have taken in our hauls.

The points of greatest interest are the large size and forward direction of the eyes, the presence in the egg of the larval balloon skin, and the absence of a free-swimming larval stage. This fish would have hatched in a day or two with perfect post-larval outline, eyes and fins.

Linophryne brevibarbata sp. nov.
(Adult and post-larva)

Type: *Number* 11,656, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 308; *July* 16, 1929; *nine miles southeast of Nonsuch;* 900 *fathoms; standard length* 33 *mm.*

Field Characters: A stout, short-bodied ceratioid, black, with pale buffy fins, illicium and barbel; iris iridescent green; moderate sphenotic and short opercular spines; illicium bulb with short tentacle; barbel with three short, stout branches, each lined with five to eight blunt, finger-like processes, not extensible.

Measurements and Counts: Total length 44 mm.; Standard length 33 mm.; depth 22 (in length 1.5); head 20 (in length 1.65); eye 2 (in head 10); snout 4.8 (in head 4); maxillary 9.3 (in head 2.1); pectoral 16; pectoral length 4.3; caudal 8; caudal length 11; illicium total length 3.5; barbel total length 4.3.

General Description: Body nearly oval, the tail end broader; back and abdomen evenly curved, snout rather stout; eye large, iris brilliant green; nostril openings close together on a rounded tubercle arising on a large, conspicuous mound, on each side of the illicium base, and considerably nearer the tip of the snout than the eye; teeth much broken and worn, about six pairs in the upper jaw and nine or ten in the lower, several forming an irregular second row; the anterior teeth are larger than those behind; a pair of small vomerine teeth; the skin is black and smooth, and has a sparse network of several long, meander-

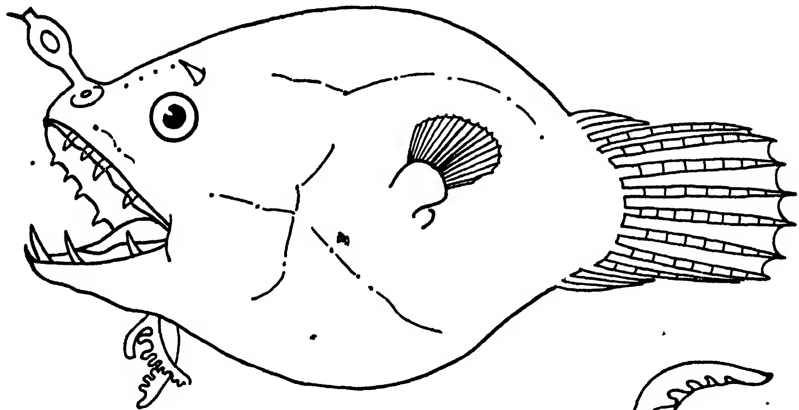
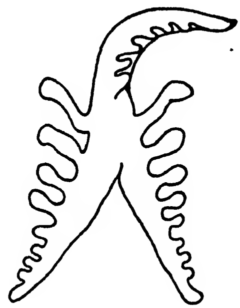


Fig. 26. *Linophryne brevibarbata* sp. nov.



ing, white threads, marked at intervals by round, glandular openings; the moderate sphenotic spine points obliquely forward, the small opercular spine is directly out at right angles to the body.

The dorsal and anal fins project beyond the skin only a short distance, and lie close to the dorsal and ventral base of the caudal; the rays are densely sheathed in thick epidermis; but they seem to number three in each fin; the pectorals of sixteen rays are well-developed, well back and are just above and partly over the gill-openings; the caudal is long and tumid, the eight rays being thickly encased in tissue.

The illicium stem is short and enlarges at once into a largish, oval bulb, translucent with a dark blue, oval core, and slightly frosted at the upper end; beyond this is a short stem which gives off a single anterior tentacle, and two posterior tentacles. The barbel is apparently full-sized, but quite unlike that of any other member of the genus; it consists of three short, stout branches, each lined on one side with five to eight short, thick tentacles, varying from low distal tubercles which grade into finger-like processes.

Post Larva: An immature specimen of this form of *Linophryne* is recorded as Number 18,535; Net 882; taken September 13, 1930; 10 miles South of Nonsuch; depth 700 fathoms; standard length 26.4 mm.

This larva was of the usual balloon-skin type, the outer skin finely vermiculated with dusky, but translucent; the dorsal surface of the inner skin of the head, and the opercular region coarsely dotted with large black chromatophores; an irregular band, several chromatophores broad, along the lower side of the inner vertebral body.

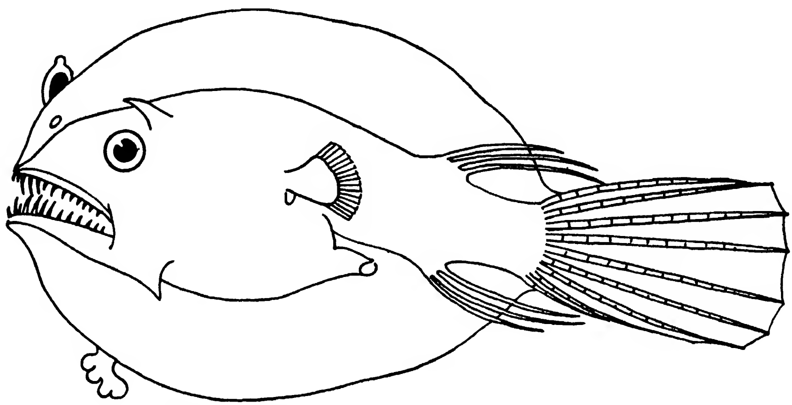


Fig. 27. *Linophryne brevibarbata* sp nov Post-larva.

The large bulb with frosted tip appears just above the surface of the skin, the inner blue core very large and conspicuous; a chin barbel shows the general shape of that of the adult, but is short, and with only a suggestion of the tubercles and tentacles; the anus is sinistral, the teeth are fairly even and more numerous than in the older specimen; in one-half of the upper jaw sixteen teeth, three anterior on each side very short and grouped closely together, a longer canine on each of the inner sides of the open symphysis. In a lower half jaw there are eighteen, in graded fives, set obliquely, several of which are probably replacement teeth.

In the cleared and dyed aspect, the vertebrae are seen to be slightly ossified, the jaws and caudal rays very strongly, and the opercular apparatus, the widely separated dorsal cranial bones, and the vertical fin rays with a medium amount of ossification.

Lophodolus lyra sp nov.

Type: No. 21,610, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1,111; *July* 27, 1931; *ten miles south of Nonsuch; Depth,* 800 *fathoms; standard length* 47 *mm.*

Field Characters: A small, dark brown ceratioid, with very large mouth and head, small eyes, and numerous teeth of small size. A short, thick illicium bears a dark ball at the tip with a terminal pair of snow-white, lyrate tentacles.

Sphenotic, quadrate, mid and posterior mandibular, and symphysial mandibular spines present. There are six dorsal and five anal rays, only four in each fin projecting above the skin.

Measurements and Counts: Total length 53 mm, standard length 47 mm; depth of head 19.3 (in length 2.4); head 20 (in length 2.4); eye .86 (in head 23.2); snout 5 (in head 4); maxillary 9 (in head 2.2); mandible 13.5 (in head 1.4); pectoral fin 18 rays, length 4.5 mm; dorsal 6; anal 5; caudal 9; illicium basal bone 4.3; stem 5.7; tentacles 4.3 mm.

General Description: The head of this fish is enormous, going into the length two and a third times. The dark brown skin covers all the fin rays. The head is strongly curved above, while the comparatively straight ventral outline is broken by the sharp posterior angle and spine of the mandible. The peduncle is thick and parallel-sided and the tail fin continues the same width.

The eyes are very small, going over twenty-three times into the head, but they are bright and functional; the nostrils are placed in a single, tubular tentacle, half-way between the snout and eye, the two openings placed respectively at the summit and half-way down the posterior side; the mouth is very large, with an enormous gape, and placed at a 35° upward angle.

Teeth: In the maxillary the teeth are very numerous and small; in one-half of the mandible there are about thirty teeth, half of which are twice as long as the rest.

Skin: The skin is smooth, while scattered over the body from snout to tail, in meandering lines, are numerous, small, flattened filaments, each ending in two distinct openings.

Spines: The sphenotic spines are very strong and large, the quadrate small, long and sharp, and the mandibular much shorter; the mandibular symphysis is extended downward into a single, compressed spine, and the infero-posterior angle of this bone is produced into a sharp spine.

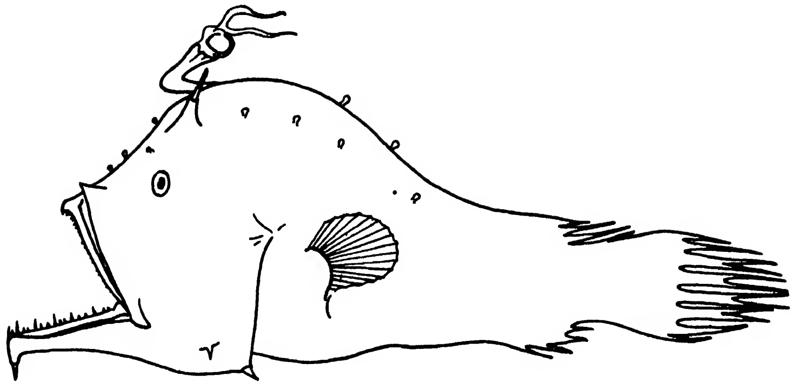


Fig. 28. *Lophodolus lyra* sp. nov.

The pectorals are placed about mid-body, the rays being 18 in number and 4.5 mm in length; there are four dorsal rays visible above the surface of the skin, set rather vertically and at the base of the peduncle; four anal rays, with the slightest suspicion of a fifth are arranged very obliquely along the ventral contour of the body. In several specimens of various ages, cleared and stained, six dorsal and five anal rays are visible, together with their muscular bases well below the surface of the outer skin. The caudal shows nine rays, the four central ones equally branched.

Illicium: This is well-developed but comparatively short and stout. Its total length is 14.3 mm. Much of the basal bone is sunken beneath the surface of the skin or in a deep trough or groove. Only the forward part is free, and elbows almost at once upward into the stem, still covered with the sepia-brown skin pigment. It immediately begins to expand into the transparent sphere which contains a large, opaque, black bulb. The upper third of this is powdered with silky white, forming a distal saddle of a tissue like silver snow, extending down in a short V in front. From this point there extend upward, from the very summit, two long, snow-white, lyrate tentacles, thick at the base, tapering rapidly.

Discussion: This ceratioid is not rare. I have taken about 40 specimens in my limited area of operation, from 600 to 1000 fathoms, more than half being in the 900 and 1000 fathom nets.

Melanocetus murrayi Günther
(Post-larva)

Specimen Number 21,516, *Bermuda Oceanographic Expedition, New York Zoological Society; Net* 1097; *July* 24, 1931; *ten miles south-west of Nonsuch;* 700 *fathoms; standard length* 9.3 *mm.*

Field Characters: A small, globular, pneumatic-skinned, buffy orange ceratiad, pectorals and caudal well-developed, about half of vertical fins projecting through skin; nostrils large.

Measurements and Counts: Total length 13.5 mm.; Standard length 9.3; depth 7.8 mm. (in length 1.2); depth inner body 5 (into length 1.8); head 5 mm. (in length 1.8); eye 1 mm. (in head 5); snout 1 mm. (in head 5); mandible total length 2.3 mm.; pectoral 15, pectoral length 1.4 mm.; dorsal 13; anal 4; caudal 11.

General Description: The external outline of the fish is almost circular, the outer epidermis coming into contact with the fish itself only at the mouth, nostrils, eyes, anus, illicium and fins. This pneumatic outer skin is transparent white, finely peppered with minute black chromatophores, giving it a pale bluish appearance. The anterior profile of the head is rounded steeply, being slightly broken by slightly protruding lips and the small mouth. The curve of the ventral profile, while almost circular is compressed and ends just in front of the anus. The base of the anal fin is oblique, and that of the caudal is vertical. The dorsal fin rays arise from the beginning of the even dorsal curve.

The inner body proper is rather oblong, opaque and a buffy orange becoming greenish on the head, and with considerable dark markings along the dorsal aspect of the trunk muscle bands and on the posterior abdomen. The smooth surface of the inner body is broken, first by the basal bone of the illicium, slender but distinct, which arises from between the eyes, slopes sharply forward and upward, and when near the outer skin over the vertical of the nostrils, sends a very short branch straight up to a pore on the mid-snout.

The eyes are well-developed, and the iris is bright, shining bluish above, and orange for more than the lower half. They are sunken deeply in the epidermal sockets, a normal condition at this stage, for the outer skin is raised considerably away from this part of the head. The nostrils are unusually large, their depth being slightly more than the diameter of the eye. The vision during this pneumatic stage must be rather limited, and the unexpected size of the nostrils is doubtless

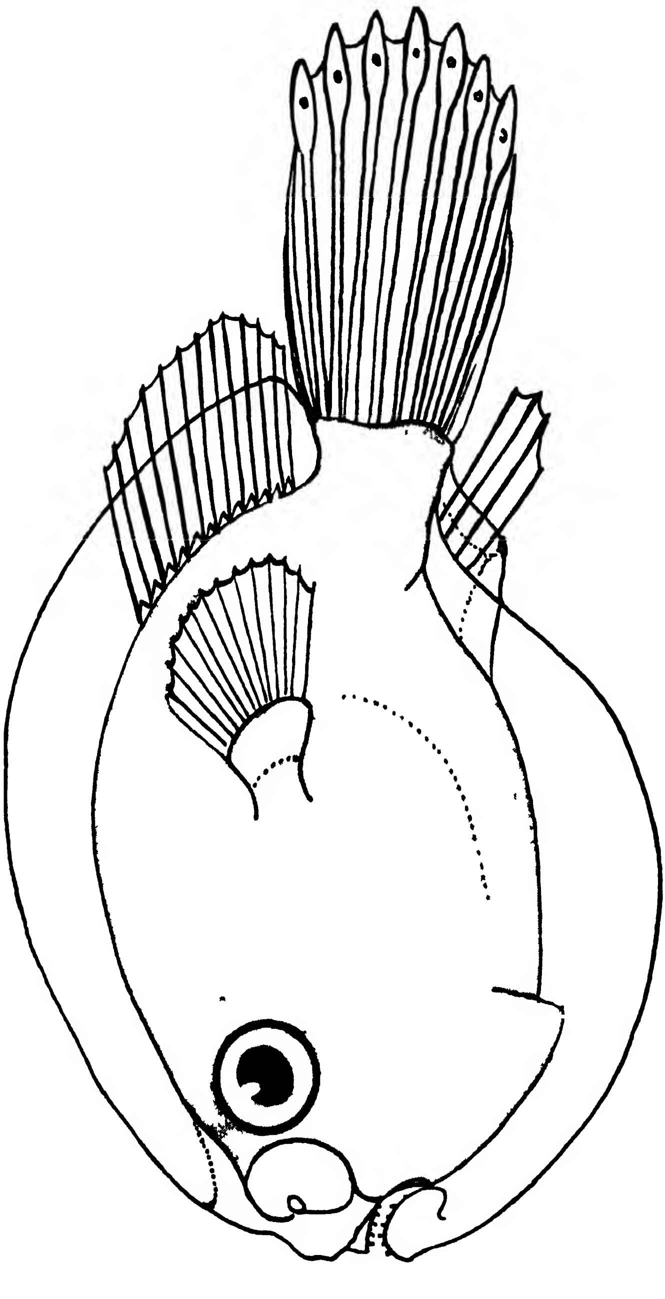


Fig. 29. ***Melanocetus murrayi*** **Günther. Post larva, 9.3 mm. standard length.**

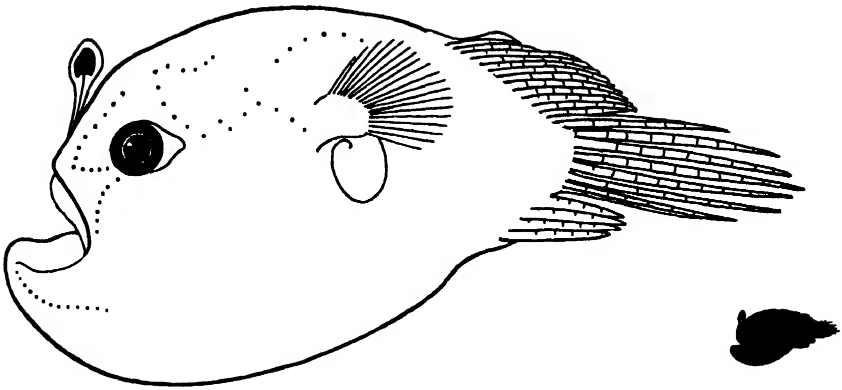


Fig. 30. *Melanocetus murrayi* Günther. Post-larva, 14 mm. standard length.

part compensation for this. The lips are noticeable; on the outside of both the upper and lower lips is a group of small, elevated glands, arranged in minute rosettes. The mouth as far as the aperture is concerned, is small, although the jaw bones are centered far back and down below the profile of the inner body, within the epidermal envelope. The teeth are numerous and minute. The anus is at the summit of a straight intestinal stalk, is median, and placed just before the anal fin.

The dorsal fin has a conspicuous, elevated base, the thirteen rays rising close together, the posterior very close to the caudal. The longest rays are 2.3 mm. long of which about 1 mm. is beyond the outer integument. Even the first protrudes into the open water. There are four anal rays.

Of eleven caudal rays, there are six which are full length, and the tips of these are somewhat spatulate, dead opaque white, with two knots of dark pigment in each. These are slightly but distinctly luminous in the fresh fish, being clearly discernible as a zone of light of indistinguishable color. The tips of the rays of the other vertical fins are whitish and opaque, but no glow was seen. The pectorals are well-developed, about a third of the fleshy base being out of the epidermis.

More commonly taken are specimens about one-third grown, of which No. 18,445 may be taken as a typical example. It came up in net Number 881, on September 12, 1931; ten miles south-east of Nonsuch, from 600 fathoms depth; standard length 14 mm.

The body is brownish black, dead black over the coelom, revealing here and there the dark bluish iridescence over the body cavity. The iris is dark blue with a sparse scattering of silver flecks. The eye socket is pale grey and the downward slant must allow much more of sideways and downward vision than in the adult stage. The illicium stem and bulb are free of the skin, and together measure 2.2 mm. The illicium stem is pale greyish, the bulb dark blue, terminal thickening pale. Nostril leaf tissue pale. The vertical fins dead white, with considerable basal black pigment, which extends a short distance up the rays and ends abruptly. The teeth are very small, scarcely visible above the lips.

Discussion: The ceratioid fish *Melanocetus murrayi* is not uncommon in our Nonsuch hauls. We have taken fifteen specimens up to 117 mm. in total length. Of these there has been a steady increase in numbers from 600 to 1000 fathoms, with June and July as predominant months. One other specimen of post-larva besides that described was taken curiously enough, on July 24, 1929, at 800 fathoms depth, the same depth and exactly two years before the one described above.

The changes from the post-larva to the adult are chiefly increase in size of teeth, complete reduction of pneumatic, dermal envelope, and the development and breaking through the skin of the illicium.

The greatest change in any one organ in ontological development is in the relation of eye to head, which is 5 in the post-larva, 6.4 in the one-third grown, and 24 in the adult.

Aceratias edentula sp. nov.

With notes on *Aceratias* in general.

Type: No. 20,751, *Bermuda Oceanographic Expedition, New York Zoological Society, June* 2, 1931, 1000 *fathoms depth, thirteen miles south-southeast of Nonsuch, Bermuda; Standard length* 19.6 *mm.*

This small, dark Ceratioid differed outwardly in no radical respects from the descriptions of *Aceratias macrorhinus*.

It was brownish-black, except for the lips and nostrils which were white. In standard length it measured 19.6 mm. while the 6.4 mm. of tail fin gave a total length of 25 mm.; the depth 5.7 mm. went into the length 3.4; the head 7.5 mm. into the length 2.6; the eye was 1.3 mm.

in diameter, into the head 5.7; the snout 1.8 mm., into the head 4.2 times.

The dorsal and anal fins each showed the very short tips of two rays, which barely appeared above the skin half-way down the peduncle. The caudal, covered like the rest of the body with black opaque skin, showed six rays. The sphenotic spines are well developed; the nostrils were strongly protuberant and of great size; the eyes were large, well-developed and telescopic, directed obliquely forward. This is the résumé of a careful examination of the fish, less than an hour after capture.

I had the fish cleared and stained at once by Miss Hollister (KOH Number 871), and within a week the opaque dermal pigment had been completely removed with ultra-violet rays, and it was satisfactorily transparent.

The bones showed complete ossification, and the most superficial examination revealed many unexpected characters. The dermal envelope, which was of considerable extent, had become perfectly hyaline, and the real body showed a depth of only 3.5 mm., a new relation to the length of about 6 times.

Instead of two dorsal rays we find six, the tips of four not reaching the external skin, and there are five instead of two anal rays. The six caudal rays visible in the fresh fish now become nine, four above and five below the mid-line. The lowermost takes no stain and is very difficult to see except at the very base where it is faintly pink. There are twenty vertebrae. The sphenotic spines are well developed.

There is a very thin, straight illicial basal bone identical in structure with the one I have described for *Haplophryne hudsonius** even to the presence of the minute particles of bone some distance back from the tip. It extends forward and obliquely upward from its origin in the center of the supraoccipital. The anterior end is flattened laterally and for a long time I could detect no terminal attachment. It seemed to end in mid-tissue. But by careful manipulation of light, a short column of unstained tissue, perhaps pre-cartilage, became clearly visible, extending straight upward and ending in a distinct epidermal pore. I gave the specimen to two of my assistants and in the course of ten minutes both had located and identified the entire illicium structure—

*Zoologica, Vol. XII, No. 2, p. 35.

the basal bone with its complex musculature, the slender colorless vertical stem and the open pore at the surface of the epidermis. The latter was quite invisible in the fresh specimen. The musculature (four pairs at least) of the basal bone is as powerful as in fish with an elaborate, free illicium which can be moved back and forth.

Parenthetically may I add that if the clearing and staining is done carefully and with constant readjustment to the type of fish, whether solid or flabby-fleshed, scaled or naked, structures such as the various body organs, cartilage, illicium stems, bulbs and pores are extremely easy to detect and to differentiate in great detail. Osseous tissue is only the more deeply stained and the more obvious of the bodily structures.

In this species at least, if not in the genus as well, this illicium stem, arising at the anterior tip of the basal bone, completely negatives the idea that the rostral denticle has anything to do with a vanished, anterior dorsal ray. When Parr propounded this idea I welcomed it gladly as accounting for the troublesome, new osseous structure at the tip of the upper jaw, but in *Aceratias* it seems we must look for some other explanation.

The superior rostral denticles are strongly developed, a median and two, lateral, large, curved fangs firmly implanted in a basal bony shield —shaped like a convex triangle with a deep curved bay between the two lower points. It has no close connection with any bone and only a very slight one with the rostral cartilage.

There is a remarkably radical modification of the upper jaw proper. The premaxillaries are closely opposed along the median line in a pronounced symphysis, but send out only very short, slender, lateral arms. In size, position and shape they resemble the premaxillaries of fish wholly unrelated to a Pediculate. The maxillaries are reduced to slender rods of bone which rise outside the mandible, about four-fifths of the distance to the quadrate, extend forward to within a fourth from the mandibular symphysis, and there end in short, two-pronged forks, the inner of which connects with the lateral arms of the premaxillaries. The upper jaw is therefore much shorter than the lower and modified out of all normal proportions.

The mandible is strong, deep and perfectly developed. It bears no teeth but has irregular nicks and two fairly deep scallops in the rim.

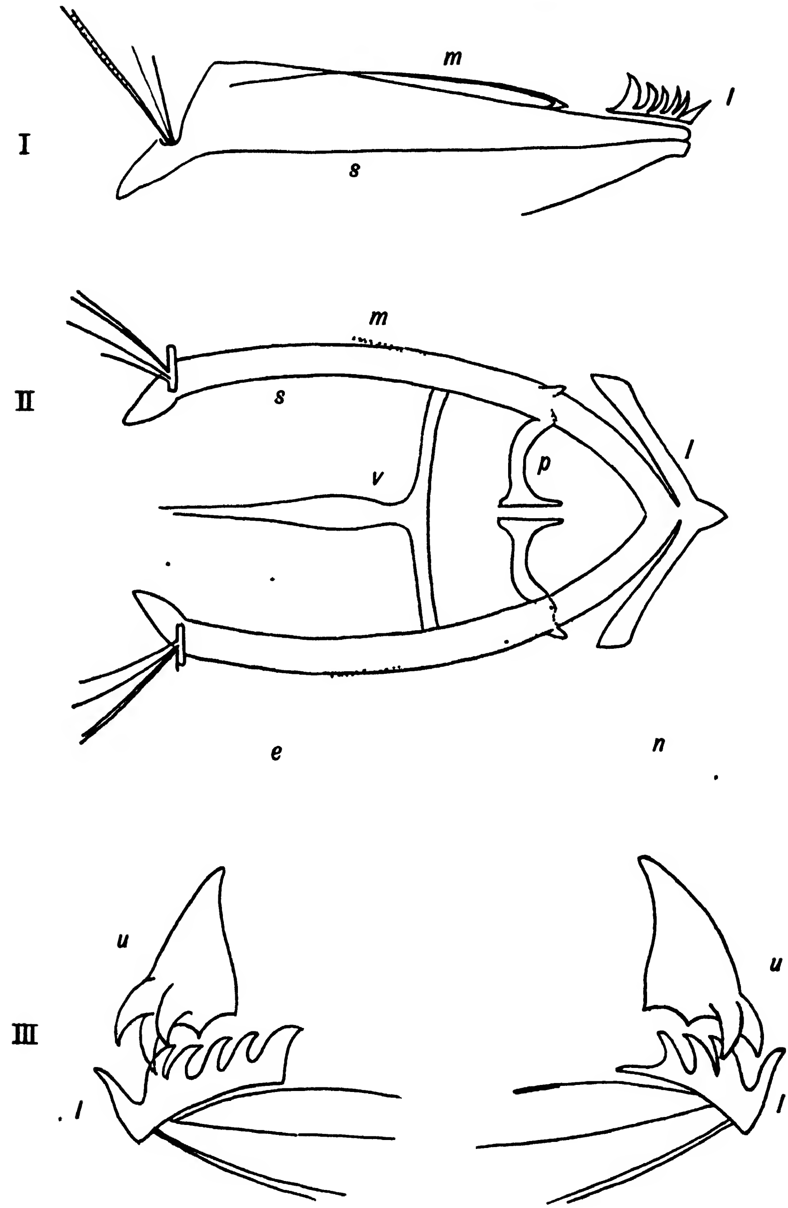


Fig 31 *Aceratias edentula* sp nov Jaws
I Lateral view, II Upper view, III Right and left lateral views of rostral denticles
u Superior rostral denticles l Inferior rostral denticles. m. Maxillary p Premaxillary.
s Mandible v Vomer

These latter fit into corresponding but much shallower curves in the maxillary. Arched over the anterior part of the mandible, and extending a considerable distance back of the symphysis is a large, angled bone, a solid base from which spring nine strong fangs, all sharp and curved, except the median one which extends straight upward. The central ones interlock with the superior rostral denticles. This bone with its nine teeth is quite free from the mandible even at the symphysis where they approach closest. Curiously enough this bone while quite unbroken and thoroughly ossified, is asymmetrical. It is slightly longer on the left side where it bears five teeth, than on the right which bears only three curved fangs. This bone, while it offers no absolute proof of the origin of the superior denticles, yet obviates the necessity of accounting for them by a connection with the dorsal rays, for there is no possibility of calling on the anal fin to perform a similar service for the mandibular denticle plate.

When we remember the astonishing spines, barbules, tentacles, photophore organs and scales in this order of fishes, the independent appearance of a pair of osseus plates is not unreasonable—structures doubtless intended to subserve some highly specialized function.

To check up on all the above details I have re-examined specimen Number 15,867, taken in Net Number 689, on June 9, 1930, at a depth of 1000 fathoms. It had a standard length of 15.8 mm., with a total of 24.3 mm. In the presence and development of the basal bone, illicium stem and epidermal pore it offered no differences. The jaws too were edentulous except for a solitary tooth on the mid-right mandibular ramus, very weakly developed. The remainder of the mandibles showed slight rugosities. The degenerate upper jaw was like the larger specimen. The two rostral denticle ossifications are so much like those of the other fish that they even share asymmetry. The three large fangs in the upper plate do not radiate evenly, but are turned, one to the right and two to the left. The mandibular plate has three teeth on the right and five on the left, exactly like that of the other specimen. Here again we are forced to the conclusion that those two structures have originated independently of any preceeding organ, and cannot be correlated with any definite structure in other groups of fish.

The suggestion of Parr seems very probable that these small Aceratiids are the free-swimming males which, according to Regan's

astonishing discoveries, sooner or later attach themselves, parasite-like, to much larger females. It is likely that not all the subsequent degeneration of osseous and visceral tissues takes place after the growing together of the two sexes. With this possibility, any hard and fast classification based on ordinary organs becomes a difficult matter. For example, according to the latest diagnostic table my specimens Number 20,571 and 15,867 line up as follows:

Telescopic eyes Enormous nostrils Sphenotic spines Closed jaws Sub-dermal vertical fins	Aceratias
Edentulous jaws	Rhynchoceratias

Other minor characters could be added, but these are sufficient to show how one or two additional specimens can upset preconceived ideas. I feel that any detailed view as to the evolution and exact relationships of these abyssal fish should wait for the examination of hundreds instead of individuals. Rather however than confuse the ultimate issue by assuming an amazing variation in a single species, I have chosen to reject the edentulous jaw condition as chief generic differentiation, and recognize the extremely degenerate upper jaw, etc., as of specific value.

Aceratias edentula differs from *macrorhinus* as described by Brauer in various proportions; the depth being slightly less, the head larger, the eye and the snout considerably smaller. The differences in dorsal and anal fin count is due probably to the subdermal character of these organs. *Edentula,* unlike *macrorhinus,* lacks all regular teeth on maxillary and mandible, and has the upper jaw degenerate, if not atavistic, while the rostral denticles and plates are strongly developed, three fangs on the upper and nine on the asymmetrical lower.

NEW BERMUDA FISH,

INCLUDING SIX NEW SPECIES AND FORTY-THREE SPECIES HITHERTO UNRECORDED FROM BERMUDA*

BY WILLIAM BEEBE AND
JOHN TEE-VAN

During the three seasons' work (1929, 1930 and 1931) of the Department of Tropical Research of the New York Zoological Society at Nonsuch Island, Bermuda, the following species of apparently undescribed shore fish were taken, all within a radius of two miles of the island. The type specimens are in the collections of the Department of Tropical Research. Illustrations of these forms will be given in forthcoming publications on the fishes of Bermuda.

LIST OF SPECIES

* Contribution, Department of Tropical Research, New York Zoological Society, No. 368.

Quassiremus goslingi sp. nov.

Type: No. 8700, *Bermuda Oceanographic Expedition, New York Zoological Society, Captured with hand line at 30 feet depth, Castle Roads, Bermuda, March* 21, 1929, *Length* 652 *mm.; Paratypes: 2 specimens,* Nos. 25,150, (623 mm.) *and* 25,151 (710 mm.), *captured at same time and place.*

Field Characters: Elongate, cylindrical, firmly-built eels with tip of tail forming a hard point, the dorsal and anal fins ending before the tail tip; pectoral fins rudimentary, visible as a minute flap immediately back of the gill-opening. Brownish with conspicuous dark brown, orange and red spots, pale below.

Measurements and Counts: (Type) Length 652 mm.; trunk plus head 361 (1.8 in length); trunk 304 (2.14 in length); tail 291 (2.2 in length); depth 24 (27 in length); width of body 23.5 (27.7 in length); snout to dorsal fin 74.5 (8.7 in length); head 57 (11.4 in length); eye 5.6 (10 in head); interorbital 7.8 (7.3 in head); snout 12.5 (4.5 in head); snout to gape 21 (2.7 in head); width at gape 13 (4.38 in head); pectoral length 1 (57 in head); length of pectoral base 3.8 (15 in head); gill-opening 6 (9.5 in head).

Description: Body elongate, cylindrical, flattened slightly on the ventral surfaces, the tail tapering from the anus to its tip, ending in a stiff hard point. Depth and width of body almost equal, the depth of the body 2.25 to 2.5 in the head.

Lateral line beginning on the head above the gill-opening, continued along the middle of the sides, consisting of approximately 125 well-marked pores.

Head tapering anteriorly, the sides flattened, the region of the gill-covers somewhat swollen. Snout tapering, its dorsal view abruptly rounded anteriorly, the snout extending about one-half an eye's diameter beyond the tip of the lower jaw.

Eye 10 to 11.3 in the head, 2.3 to 2.5 in the snout, elliptical, its long axis horizontal, the upper margin reaching the dorsal profile, its outer transparent lid continuous with the skin of the head.

Anterior nostril in a short, downward-pointing tube not quite at the tip of the snout. Posterior nostril aperture almost as large as the anterior, rounded, situated within the upper lip just below the anterior end of the eye, concealed by a dermal flap which begins just anterior to the nostril.

Mouth medium in size, the jaws straight and closing completely, the gape extending half an eye's diameter beyond the eye.

Teeth conical, pointing backward. Two or three large, curved teeth at the anterior part of the jaw, maxillary with 12 to 14 teeth on each side. Mandible with 13 to 14 teeth in a single row on each side. Vomerine teeth in a single row, 14 in number, the anterior 5 much larger than the others.

Gill-openings small, their openings slightly greater than the eye's diameter, situated on the lower sides, almost vertical, the distance between them, ventrally, equal to about twice the length of the slit.

Dorsal fin depressible in a deep groove, its supporting rays rather high, their height more than half the depth of the body. Anal fin similar to the dorsal in height.

Pectoral fins minute, represented by a dermal flap at the upper end of the gill-opening, their base about one half the length of the gill opening.

Color in life: General color of sides above the lateral line salmon-buff, changing abruptly beneath the lateral line to creamy white. Seventeen saddle-like markings of salmon-orange along the dorsal surface, these spots becoming darker centrally, this darkening most pronounced on the three last markings. A series of large light orange spots which shade to deep chrome in the center, on the mid-sides, one between each of the saddle-like markings. Between the upper saddles and the lateral spots are smaller, similarly-colored spots, the majority with dark centers. Snout with a pinkish buff background and with small irregular blackish spots. Back of the eye these spots enlarge and change to antique brown. Iris pale gold with dark markings anteriorly and posteriorly. Lateral line pores white, conspicuous from head to tail. Dorsal fin marked with pale orange spots, somewhat like those on the body, the fin margined with white. Anal fin transparent, with a few orange spots posteriorly.

Discussion: The only previously recorded species of *Quassiremus* from the Atlantic is *Quassiremus productus*, described by Seale in 1917 from the Bahama Islands, as the result of a specimen taken in 1861. The present species differs from *productus* in the following particulars:—smaller mouth, the distance from the snout to gape 2.7 to 3.1 in the head as opposed to 2.3 in *productus;* the posterior nostril is a rounded hole, not a slit; eye 2.1 to 2.5 in the snout, not 1.7 as in *productus;* pores of the lateral line prominent; dorsal and anal fins high; somewhat different color pattern.

Name: We take pleasure in naming this remarkable new eel for the Honourable F. Goodwin Gosling, to whom we owe the first suggestion of using Nonsuch as a scientific station, and whose kindness in Bermuda, to visiting scientists, has become proverbial.

Exonautes nonsuchae sp. nov.

Type: No. 9983, *Department of Tropical Research, New York Zoological Society, in Sargassum weed near shore of St. David's Island, Bermuda, May* 15, 1929, *Standard length* 24.5 mm.

Field Characters: Very small, four-winged flyingfish without jaw barbels, and with 13 anal rays. Pinkish above with vertical orange cross-bars on the sides. Tips of pectorals and ventrals bright orange, the base of each fin with a dark black or blue spot. Tips of dorsal and anal fins orange.

Measurements and Counts: Length, total 30.3 mm.; length, standard 24.5 mm.; depth 3.8 (6.4 in length); width of body at gill-openings 3.8; head 5.8 (4.2 in length); eye 2.4 (2.4 in head); interorbital 2.4 (2.4 in head); snout 1.2 (4.8 in head); snout to pectoral origin 5.3; snout to ventral origin 13; snout to dorsal origin 15.5; snout to anal fin 16.5; length dorsal base 5.2; length of longest dorsal ray 4.1; length anal base 4.5; length longest anal ray 3.5; length lower caudal lobe 7.5; dorsal fin 12 rays; anal 13 rays; 49 scales in a lateral series.

Description: Rather elongate, the profile from eye to origin of dorsal fin straight, the anterior portion of the dorsal fin base raised; head from snout to above posterior portion of eye straight, but at a considerable angle from the back; snout short, pointed when viewed either from the side or above; eye large, circular, entering the upper profile; mouth small, oblique; maxillary small, almost vertical, its posterior margin reaching to the anterior margin of the eye.

Dorsal fin high anteriorly, becoming considerably shorter posteriorly; anal fin similar but not as markedly so, the latter fin beginning beneath the 2nd and 3rd dorsal ray. Pectoral fin with 18 rays, the first two parallel and very close together, the anterior slightly shorter than the second and simple, the second ray branched; 6th and 7th rays longest, the 5th and 8th equal in length, the 3rd, 4th and 5th becoming progressively longer in almost equal amounts; the adpressed pectoral fin reaches to next to the last ray of the

dorsal fin. Ventral fins prominent, the tip of the adpressed fin reaching slightly beyond the anal base.

Color: (See Frontispiece of "Nonsuch; Land of Water" for color plate). In life,—general color of body somewhat pinkish with six vertical orange bands on the sides, the posterior one below the posterior tip of the dorsal fin. Posterior portion of caudal peduncle dark blue. Upper parts with small scattered bluish chromatophores. Dorsal fin orange superiorly with a small dusky spot at the tip. Anal fin orange distally, with a blackish tip. Caudal fin colorless. Pectoral fin bluish-black at base, its anterior outer portion bright orange, with scattered black chromatophores along the rays and along the margin of the fin; a small dusky spot in the center of the fin near the orange portion. Ventral fins with a blackish spot at their base, in the center of which is an orange spot; distal $3/5$ of ventral fins bright orange with dusky toward the tip of the rays.

In preservative the entire body is dusky blue-gray. Vertical fins slightly dusky, the anterior tip of the dorsal with a dusky patch. Pectorals transparent with the exception of a dusky patch at the base and an irregular patch of dusky along the anterior edges, this patch widest and most prominent at the outer tip of the fin. Ventral fins dusky at base and on outer $3/5$ of the fin, the remainder transparent.

Discussion: The present species does not answer the descriptions of any of the Atlantic flyingfishes sufficiently well to assign it to any definite form. Until its relationship to some adult form can be established, it seems best to give the present specimen a new name.

It is of interest that this species, as well as *Cypselurus furcatus* and other young of *Exonautes* which live in Sargassum weed, should all possess a broken and mottled wing-pattern.

Corythoichthys bermudensis sp. nov.

Type: Male, No. 9326, *Bermuda Oceanographic Expedition, New York Zoological Society, Nonsuch Island, Bermuda,* August 18, 1930, *standard length* 61 mm.

Field Characters: Small, rather short and robust pipefish with upturned snout and dorsal fin of 23 rays on O body and 7 caudal segments; 17 body and 26 caudal segments; greenish-brown, somewhat mottled and with vertical, irregular lighter patches.

Measurements and Counts: Length, total 64 mm.; length, standard 61 mm.; head and trunk 26.5 mm. (2.3 in length); tail 34.5 (1.77 in length); depth 3.8 (16 in length); head 6.5 (9.4 in length); snout 2.1 (3.1 in head); eye 1.2 (5.4 in head); post-orbital head 3.3 (1.97 in head); snout to origin of dorsal fin 27; pectoral length 1.6; caudal fin length 3; dorsal fin 23 rays on O plus 7 segments; pectoral 11 rays; caudal 9 rays; body segments 17, caudal segments 26.

Description: Snout short, upturned, with a slight median crest which ends between the orbits; after a short space this crest begins again and ends on the nape. A small supra-orbital ridge, and a small but well-developed ridge on the opercle, from which small striations radiate downward and backward. All of these ridges are smooth and not serrated.

Superior trunk crests end just before the posterior end of the dorsal fin; median lateral trunk crest ends on the last body segment, slightly below the middle of the sides, with no indication of any attempt to join the lower body ridges. Superior caudal crest begins on the last body segment, below the superior trunk ridge and roughly paralleling it until the caudal ridge ascends to its position on the caudal portion of the body. Inferior trunk and caudal crests continuous. Dermal appendages not present.

Brood pouch extending on 15 caudal segments, its dermal flaps not meeting on the mid-ventral line.

Color: Body mottled greenish brown, the lower surface of the trunk greenish; dull yellowish, irregularly margined vertical bands on the body and trunk,—about 8 on the trunk, these conspicuous mostly on the dorsal half of the sides, about 9 on the tail, these widest on the upper half of the sides; a series of small brownish spots on the keels of the tail. Upper surface of the head and cheeks greenish brown, the lower surface of the head and snout yellowish. A brown line on the snout from eye to angle of mouth. Dorsal fin with small brown spots on the rays.

Discussion: In Parr's key (1927, p. 30) to western Atlantic *Corythoichthys*, this species is closest to *C. cayorum* Evermann and Kendall 1897. It differs from the latter in various counts and proportions, and when compared with the original plate of *cayorum*, markedly in the lesser size of the head ridges.

Syngnathus pipulus sp. nov.

Type: No. 25,152, *Bermuda Oceanographic Expedition, New York Zoological Society, The Reach, Bermuda, October* 25, 1931, *Standard length* 113 mm.

Field Characters: Pipefish with short tail (26 caudal segments); short dorsal fin of 22 rays on 1 body and 4½ caudal segments; yellowish buff mottled with greenish.

Measurements and Counts: Length, total 116.5 mm.; length, standard 113 mm.; head and trunk 52.5 (2.15 in length); tail 60.5 (1.87 in length); depth 5.5 (20.5 in length); head 15.2 (7.4 in length); snout 7.4 (2.05 in head); eye 2.3 (6.6 in head); post-orbital head 6 (2.5 in head); snout to dorsal origin 49.5; pectoral fin length 2.5; caudal length 3.5; body segments 18; caudal segments 26; dorsal fin with 22 rays on 1 body and 4½ caudal segments; pectoral rays 13; caudal rays 7.

Description: Snout rather long with a low serrated ridge extending from about ⅓ the distance from the snout to the eyes, and ending at the anterior margin of the orbits. A slightly serrated ridge on the nape. Supraorbital ridge extending slightly back of eye.

Superior body ridge ending on the 4th caudal segment. Superior caudal ridge beginning on the last body segment; median lateral body ridge ending on middle of sides of last body segment. Inferior trunk and caudal ridges continuous. Head and body with small dermal tentacles, especially prominent on the body ridges.

Marsupium extending on 20 caudal segments, containing eggs.

Color: (Preserved specimen) General color dull yellowish buff, the sides and upper parts mottled with brownish. Narrow transverse bars of pale dull yellow on the upper surfaces and vertical bars of the same color on the sides,—4 on the body segments and 9 on the caudal. Under surfaces, especially the caudal portion of the body, with transverse brownish-green bands. Snout mottled with brown. Fins colorless.

Eucinostomus mowbrayi sp. nov.

Type: No. 9328, *Bermuda Oceanographic Expedition, New York Zoological Society, Nonsuch Island, Bermuda, September* 30, 1930, *standard length* 140 mm.

Field Characters: Small, somewhat elongate, compressed,

bright silvery fishes with extremely protractile mouth parts; third anal spine twice as large in diameter as the second and slightly longer; first anal spine very small.

Measurements and Counts: Length, total 168 mm.; length, standard 140 mm.; depth 47 (2.98 in length); width of body 20 mm.; head 41.5 (3.4 in length); eye 14.2 (2.9 in head); snout 14 (2.96 in head); maxillary 14 (2.96 in head); interorbital 12 (3.46 in head); pectoral fin length 29 (1.4 in head, 4.8 in length); snout to dorsal fin 52; length of interhaemal spine 22; dorsal IX, 10; anal III, 7; gillrakers 7, the lowermost slightly longer than the uppermost; scales, 48 rows, 4½ rows from origin of dorsal fin to lateral line.

Description:—Body elongate, compressed, back moderately elevated; anterior profile slightly convex from snout to occiput, and again slightly convex from occiput to dorsal origin; eye large, the interorbital space slightly convex; maxillary reaching slightly beyond the anterior margin of the eye; premaxillary groove linear, widest anteriorly, not crossed by scales; preorbital and preopercle entire; gill-rakers small, 7 below the angle on the first arch, the lowermost slightly longer than the uppermost; lateral line complete, paralleling the back.

Dorsal spines weak, the fin highest anteriorly, the 2nd and 3rd spines subequal and longest, the spines becoming progressively shorter posteriorly; dorsal rays low; a sheath of scales along the base of both spinous and soft dorsal. Anal fin low; first anal spine very short; third anal spine twice as large in diameter as the second and slightly longer; a broad sheath of scales along the base. Pectoral fin not quite reaching the vent. Ventrals with a large axillary scale, their tips not reaching the vent. Caudal fin deeply forked.

Interhaemal spine similar to illustration given by Parr (1930) of *Eucinostomus havana* (Nichols), the air bladder entering a cup-shaped depression in the lower anterior side of the interhaemal spine.

Color: Silvery, darker above, no traces of cross-bars; a dusky spot at the tip of the anterior rays of the dorsal fin. Fins, except the clear pectorals, slightly dusky.

Discussion: This species is close to *Eucinostomus havana* (Nichols), but differs markedly in the relative sizes of the anal spines.

Name: Named for Mr. Louis L. Mowbray, the capable Director of the Bermuda Aquarium, who has shown us many kindnesses in the course of our work in Bermuda.

Iridio bathyphilus sp. nov.

Type: No. 9050, *Bermuda Oceanographic Expedition, New York Zoological Society, taken in trap set in 510 feet water, one mile south of Nonsuch Island, Bermuda, September* 30, 1929, *standard length* 145 *mm.; Paratypes,*—3 *specimens,* Nos. 25,045 *a, b* and *c,* 123, 121 and 89 mm. *respectively, taken at same time and place.*

Field Characters: Small, elongate wrasse from deep water with the posterior margin of the caudal fin double-concave. Brilliant in coloration with a band of green or yellow from snout to eye, which bifurcates posterior to eye, the upper bifurcation extending to the nape, the lower continued along the sides as a broken band of yellow, the yellow alternating on two scale rows. A large black or brilliant turquoise-green patch on the upper anterior sides, and sometimes with a small black patch on the body at the base of the middle caudal rays.

Measurements and Counts: length, total 165 mm.; length, standard 145 mm.; depth 34 (4.25 in length); width of body 16 (9 in length); Snout to dorsal fin 37 (3.9 in length); snout to anal fin 72 (2 in length); head, to tip of opercular flap 43.5 (3.3 in length); eye 7.2 (6 in head); interorbital space 9 (4.8 in head); snout 14.5 (3 in head); snout to gape 10.5 (4.15 in head); caudal peduncle height 16.3 (2.75 in head); dorsal fin rays IX, 11; anal fin rays III, 12; pectoral fin rays 13; length upper margin of pectoral fin 23.5; length lower margin of pectoral 10.2; ventral fin rays I, 5; length of ventral fin 21.5; length inner margin of ventral fin 10.7; scales, from upper angle of gill opening 28 to 29; gill-rakers 11 on lower half of the anterior arch.

Description: Body elongate, compressed, the caudal peduncle rather deep; ventral outline almost straight, curved upward slightly near the chin; dorsal outline considerably more convex than the lower. Anterior profile from snout to origin of the dorsal fin a gentle continuous curve. Head naked, medium in size, considerably compressed, the opercle ending in an obtuse fleshy flap above the pectoral fin. Gill membranes attached to the isthmus, only a small part of the posterior portion of the membrane free. Snout obtusely conical, the mouth terminal and horizontal, the gape reaching about two-thirds the distance from snout to eye. Lips full, with internal dermal folds. Anterior nostril with a short tube. Eye elliptical, its long axis horizontal, well below the upper profile and situated somewhat before the mid-length of the head.

Teeth;—Canines $^2/_4$, the upper canines slightly larger than the lower; teeth of the upper jaw becoming progressively larger as they progress forward, so that the teeth next to the canines are large, but are not likely to be confused as a second set of canines. A conspicuous posterior canine on each side.

Scales in 28 or 29 rows, rather large; 2½ rows between the origin of the dorsal fin and the lateral line, 1½ rows between the lateral line and the middle of the dorsal fin base. Scales of the nape becoming smaller before the dorsal fin, about six rows before the dorsal, the anterior ones difficult to observe, the rows not quite meeting across the nape. Scales on breast small.

Lateral line continuous, curved abruptly downward posteriorly, the straight portion found posteriorly on six scales only; lateral line pores simple, formed of a single canal and pore on each scale, the canal turned upward posteriorly on most of the scales.

Dorsal fin long, the first three spines becoming progressively longer, the remainder of the spines subequal and slightly longer than the third; rays more or less equal in height, higher than the spines. Membrane between spines of the dorsal continuing beyond the tip of the spines. Anal fin rays shorter than those of the dorsal, more or less equal in height; the spines weak and small. Pectoral fin base oblique, the tips of the rays not quite reaching the vent. Ventral fins originate under the posterior base of the pectorals, not reaching the vent, the longest rays somewhat filamentous. Caudal fin biconcave, the central rays as long as the outer ones.

Coloration: In life, middle of sides rich pinkish-lilac (Thulite pink of Ridgway); upper sides duller and each scale with a rich green edge; lower sides yellow and under surfaces white. Top of head and upper lip spinel pink, the lower portion of the head becoming first violet and then greenish blue. A broad viridine green band from snout to eye, broadest near the eye. Two similarly colored bands, the first from the eye to the shoulder, the second from the eye to the upper end of the preopercle. This second band is continued down the side of the fish, continuous and unbroken on the opercle, but zigzag and broken on the body,—found on alternate scales of two adjoining rows. On the upper anterior side is a rich deep turquoise spot, in shape much like two balls pressed closely together.

Dorsal fin pale blue with a pale yellow base and outer margin. Anal fin bright yellow with a blue margin and a narrow reddish-

orange band near to and paralleling the base. Pectoral fins clear translucent. Ventral fins pale blue. Caudal fin pale blue, its upper and lower margins greenish yellow, and with a blue and yellow pattern mesially as follows,—a narrow band of pale blue starting at the upper base of the fin and running to the tip of the middle rays of the caudal where it meets its fellow from the lower base of the fin; two narrower bands of similar blue inside of these, roughly paralleling them; bordering and surrounding these bands the color is bright yellow.

In one of the smaller cotypes, the pattern is similar but the general coloration of the sides is reddish pink. In this example the upper sides are reddish and the middle of the sides pink, while the yellow of the lower sides is concentrated into a band. In addition, there is a small black spot at the base of the caudal, and the central oblique bands on the caudal are lacking.

In preservative the general color is light buff, traces of the color pattern remaining with the exception of the band along the middle of the sides. This has disappeared in all of the specimens.

In addition to the species given above, the following have been added to the shore fish fauna of Bermuda. A number of these species are fairly well known to some of the Bermuda fishermen, but they are apparently unrecorded in the ichthyological literature of the island. *Pneumatophorus colias,* recorded many years ago from Bermuda but ignored by later students, is reëstablished as a Bermuda fish, on the basis of a specimen taken by us in St. Georges Harbour.

Amphioxides pelagicus Günther
Mustelus mustelus (Linnaeus)
Galeocerdo arcticus (Faber)
Carcharias falciformis Bibron
Prionace glauca (Linnaeus)
Myrophis dolichorhynchus Parr
Myrophis platyrhynchus Breder
Chilorhinus suensonii Lütken
Sphagebranchus ophioneus Evermann and Marsh
Myrichthys oculatus Kaup
Aphthalmichthys mayeri Silvester
Gymnothorax polygonius Poey
Gymnothorax albimentis (Evermann and Marsh)
Halocypselus obtusirostris (Günther)

Cypselurus heterurus (Rafinesque)
Bregmaceros macclellandi Thompson
Etropus rimosus Goode and Bean
Pneumatophorus colias (Gmelin)
Peprilus paru (Linnaeus)
Chloroscombrus chrysurus (Linnaeus)
Argyreiosus vomer (Linnaeus)
Astrapogon stellatus (Cope)
Epinephelus mystacinus (Poey)
Trisotropis dimidiatus (Poey)
Gramma hemicrysos Mowbray
Rypticus saponaceus (Bloch and Schneider)
Etelis oculatus (Cuvier and Valenciennes)
Inermia vittata Poey
Eucinostomus havana (Nichols)
Chaetodon sedentarius Poey
Clepticus parrae (Bloch and Schneider)
Xyrichthys splendens Castelnau
Scarus punctulatus Cuvier and Valenciennes
Sparisoma squalidum (Poey)
Sparisoma brachiale (Poey)
Eviota personata Jordan and Thompson
Lophogobius pallidus Parr
Gobius boleosoma Jordan and Gilbert
Gobiosoma longum Nichols
Callionymus boekei Metzelaar
Callionymus dubiosus Parr
Balistes forcipatus Gmelin
Xanthichthys ringens Linnaeus

ONTOLOGICAL NOTES ON *REMORA REMORA*

BY WILLIAM BEEBE

(Figs. 32 to 37 incl.)

OUTLINE

I. ORGANIC FUNCTIONAL CHANGE.

II. COMPARISON OF TWO REMORAS–

One 15 mm. and the other 88 mm. standard length

Cephalic Sucking Disk.

Labial Suckers.

Teeth.

Scales.

Fins.

General Proportions of Growth.

An extremely interesting as well as mysterious phase of organic, and for that matter any other kind of evolution, is not the perfect end products that we see performing their work so smoothly today, but the beginnings, the first hints of organs and structures, of functions and habits.

The most air-minded lizard which ever existed could never have become a creature of flight by launching out from trees and trusting solely to the scales on his fore-legs to fray out ultimately into wing feathers. Time after time I have seen five-foot iguanas leap into midair and when they landed in low scrub it was always their heavy hind-quarters and tail which struck first. Many years ago at the Zoological Park a pin-feathered squab gave me a hint, and from the amazingly well-developed feathers on the outside of its upper legs I turned elsewhere for additional proof and found it in the nestlings of many other birds and in the femoral wing of Archaeopteryx itself. Hence my theoretical Tetrapteryx which serves logically to bridge the first difficult beginnings in the transition from volplaning lizard to volant bird.[1]

[1] A Tetrapteryx Stage in the Ancestry of Birds, Zoologica II, No. 2, 1915.

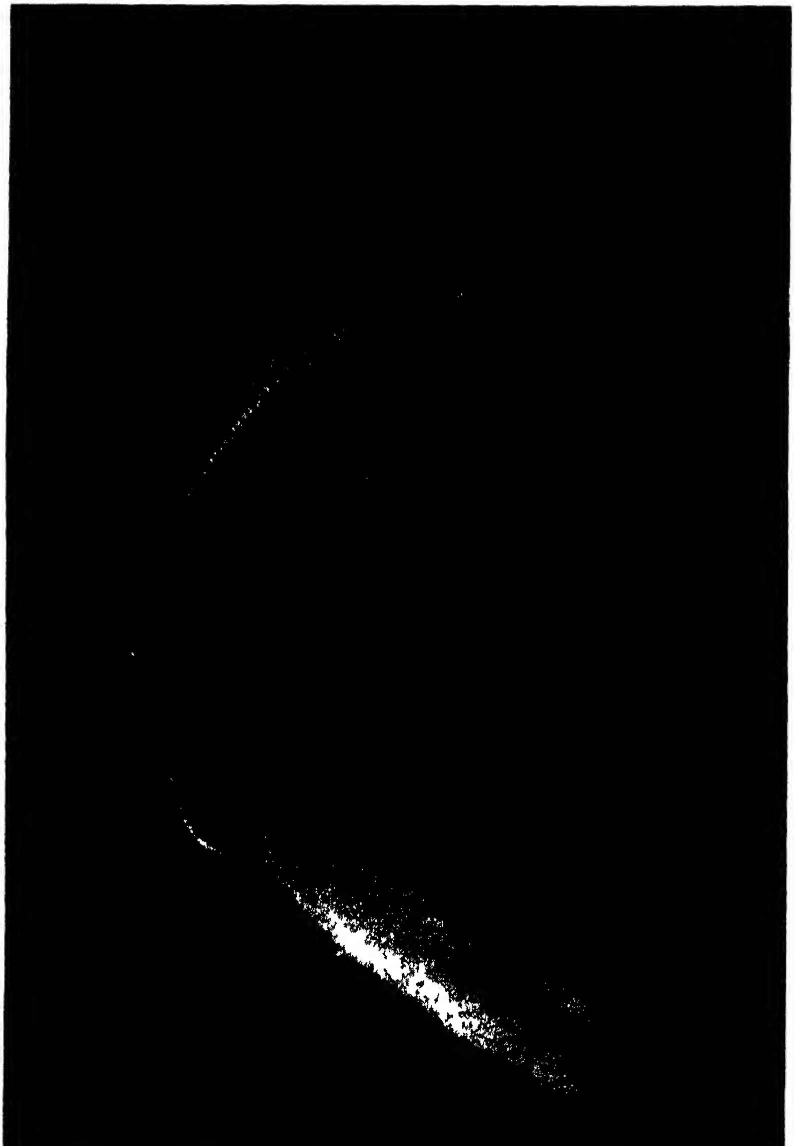


Fig 32. *Remora remora*, 88 mm. Photograph of dorsal view of head showing functional sucking disk and teeth.

Fig. 33. *Remore remora*, 15 mm. Photograph of head from above showing larval suckers.

Another missing-link-of-a-character has recently come to my attention.

The material to which the following account refers consists of two specimens of *Remora remora;* both taken on the Third Bermuda Oceanographic Expedition of the Department of Tropical Research of the New York Zoological Society.

A. 88 mm. standard length, No. 9358, KOH No. 854, taken from *Carcharias obscurus*, at surface, May 26, 1931, near Nonsuch, Bermuda.

B. 15 mm. standard length, No. 23,459, KOH No. 1013, Net 1304, 8 miles southeast of Nonsuch, 400 fathoms, September 15, 1931.

Specimen B in life was purplish brown, the anterior portions of lips, tips of pectorals and outer tips of caudal lobes pale grayish. Both fish have been thoroughly dyed and cleared.

Examining the 88 mm. *Remora*, I wondered, as often before, at the extent of the protruding under lip in these young specimens.

The dye had made the remarkable teeth stand out with great distinctness. They somewhat resembled the teeth of a horse, rows upon rows of them, raised on the end of slender stalks and aligned in long palisades. In the lower jaw were still more dental multitudes, showing sharp, incurved hooks at the summits.

Cephalic Sucking Disk

The remarkably effective sucking disk on the head was fully developed and functional in this fish. Each half of the eighteen transverse lamellae consisted of a broad proximal sheet of tissue, giving rise, along the posterior edge, to more than 70 finger-like tentacles arranged in three rows; the anterior row of shortest ones numbered 40, a middle row of medium length tentacles had 17, and the posterior row of long ones had the same number.

I next examined a much smaller specimen less than an inch in standard length, 15 mm., and was at once impressed with the simplicity and undeveloped condition of the sucking disk. It was perfect in general shape, showing no transition from the original dorsal fin from which it was derived. The rays of the fin must at some still earlier stage have split, spread out sideways and become changed into movable, transverse plates which have the power of being raised and lowered and creating a vacuum. These plates in my infant shark-sucker were very imperfect. Instead of each lamella being armed with three rows of various sized tentacles and a complicated system of water-tight compartments, each half of a transverse section possessed only 6 or 7 long, flattened, thick tentacles with no developed flaps or membranes. In fact there was sufficient basal tissue only to hold the tentacles together. Their relative length in the two fish was 14 to 2; their relative average number 74 to 6.

It was evident that this elaborate and specialized structure was still in process of development, at present quite useless as the factor in progress and movement which it had been ancestrally when a proper dorsal fin. On the other hand, it was equally unable as yet to perform its ultimate, opposite function of an anchorage, an inhibitor of movement.

Such a condition in any organ implies one of two things, either that the creature can get along for a time without the ultimate change of function of the structure, or that it has some temporary

substitute which for the time being suffices as a stop gap. A glance at the jaws of the small *Remora* showed that the latter condition had been fulfilled.

We know nothing of the habits of the newly-hatched or post-larval shark-sucker, but it seems reasonable that as it is to spend its life creeping over the body of a shark or other large creature of the sea, that the sooner it develops some method of attachment, the better.

Labial Suckers

The teeth of our half-inch fish were few in number, minute and inconspicuous, but the fleshy portion of the lower jaw was

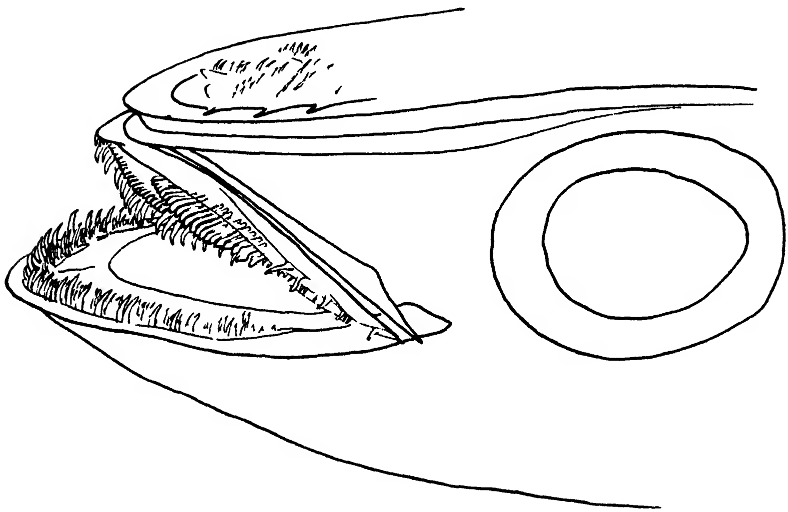


Fig. 34. *Remora remora*. 88 mm. Lateral view of head, showing complicated lines of teeth.

undershot even more than in the adult; precisely as 68 to 57, or a full fifth. This projecting lip and the anterior portions of the upper jaw were provided with a formidable armature of suckers, 26 in all. In general appearance they were like the corresponding organs on the arms of an octopus, a short, thick pedicle expanding distally into a rounded, inverted cup with a circular upper rim. The largest was .11 mm. in diameter. There were 6 along the anterior edge of the upper jaw, and 3 on each side of the symphysis, directed obliquely up and forward. On the lower jaw were 20 suckers, ar-

ranged in two rows, 12 along the edge of the jaw and 8 in a second line. Considering the suckers in one-half of the lower jaw, I found that in the first row the central four were small and placed close together, the outer two considerably larger, about twice, and well separated from each other. The second row showed a gradation in size from the symphysis outward, the outermost, however, being smaller than the corresponding one of the first row. The lower jaw suckers were directed upward and very slightly backward.

TEETH

The teeth were difficult to find, but once located were distinct. Near the front of both upper and lower jaws, but with a wide symphysial gap, was an upper row of 8 or 9 and a lower row of 8.

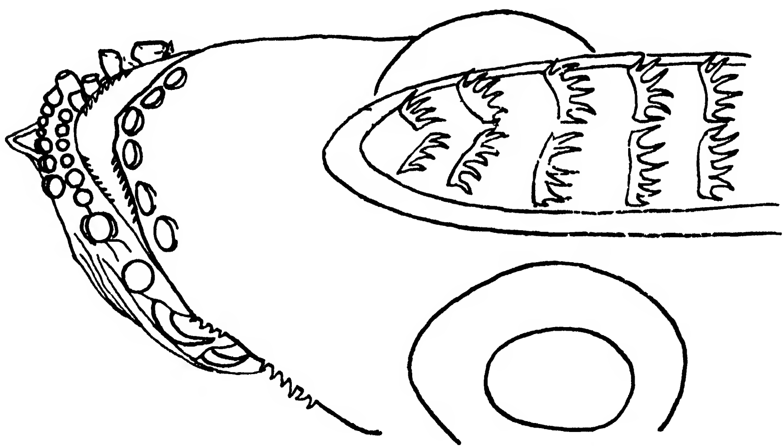


Fig. 35 *Remora remora*, 15 mm Oblique view of head showing larval suckers, and undeveloped teeth and sucking disk.

Along the lateral edge of the premaxillary, where it overhung the wandible, and beyond the outermost sucker, was an irregular row facto.ort, out-jutting teeth—10 to 15 in all.
whenMost remarkable, however, were two pairs of large, sharply able ed fangs, beyond the outermost sucker on the lower jaw, and age, ad laterally and very slightly upward. The flatness of the
Sucre, together with their extra-buccolabial position rendered that the less for the capture or retention of prey, and unless they change of f in hooking over the upper jaw, thereby locking the two

together when these are in use as an attaching organ, I cannot divine their function.

Dr. Tåning[2] has studied post-larval stages of *Remora* and *Echeneis* from the point of view of the gradual shifting forward of the cephalic disk. Although he had specimens of *Remora remora* of 5, 6, 10, 12, 18 and 25 mm., he makes no mention of labial suckers, but in his illustration shows sparse but well-developed teeth along the lower jaw from the 9.8 mm. individual up to that of 25 mm. length. The situation of the disk in my 15 mm. specimen is more advanced than in Tåning's 18 mm. fish, as he writes of this individual, "*le bord antérieur du disque est placé au bord antérieur des yeux,*" while in mine the disk extends one-third of the eye's diameter in advance of the eye's anterior rim.

Scales

Scales are wholly absent from the 15 mm. specimen and in preserved remoras of large size the skin usually shows only irregular, deep reticulations of mucus, the scales being hidden in the sunken interspaces. In my cleared individual of 88 mm. the scales are conspicuous and cover the entire surface. They are small and exceedingly numerous and very characteristic in shape. There are about 40 scales to every square millimeter and a most conservative estimate of the body area gives a minimum total of at least 100,000 scales on head, fins and body.

Superficially they remind one of nothing so much as a multitude of the bowls of table- and tea-spoons stuck obliquely into the skin, with the concavities facing forward. If they were not imbedded in mucus during life they would form most efficient brakes on any rapid forward progress through the water. At first they seem to be quite irregularly inserted, and indeed there is no hint of regular rows for more than a few scales at a time, but in about three cases out of five and even more along the sides, each large scale has two small scales sprouting from its anterior base.

In the space of a square millimeter there are 12 to 15 large scales with attendant and other scattered small scales. Sometimes there is only one small scale to a large one, or three smalls may be in a longitudinal row to fill an interspace between two large ones.

[2] *Comptes rendus des séances de l'Académie des Sciences*, Vol. 182, p. 1293.

Fig 36 Scales of 88 mm , *Remora remora*, horizontal view

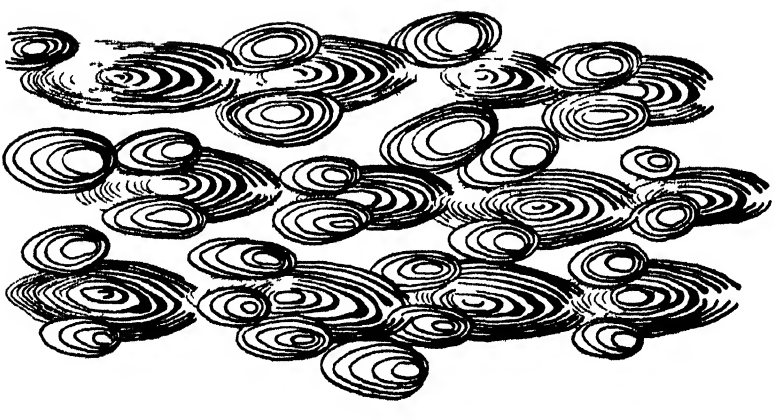


Fig 37 Scales of 88 mm , *Remora remora*, vertical view

The scales are regular ovals, the larger ones .33 and the smaller .11 mm. in length. In the cleared tissues their entire outline can be distinctly seen, all the circuli having taken up considerable stain. The rings vary from 6 to 12, usually 8, and they may be very thin and close together or thick. Starting from a small central oval they are all complete in the small scales and a few of the large ones, but in the majority of the latter they are broken or worn away at the tip so that the outermost three or four do not meet. This would suggest some use in regard to progress over the body of the shark, or of assistance in clinging. On the other hand, the terminal breaks may act as channels for facilitating the distribution of mucus. At present our safest comment is "I don't know."

The scales are identical in size, shape and structure everywhere on the fish. The only variation in arrangement is a diminishing number of small scales along the mid-back and mid-ventral areas, fewer of the regular trinities being found in these places than elsewhere. Scales occur on all available parts of the head, extend some distance up the pectorals and vertical fins, and almost to the tips on the ventrals and especially on the caudal.

The lateral line is very well marked in the dyed tissues, in the 88 mm. *Remora* the components taking up stain almost as thoroughly as bone. The line is composed of a series of deep-set, short, slenderly barrel-shaped segments, pointing obliquely out and backward, the upper end showing many fine perforations. Posteriorly these separate units elongate and form an almost continuous tube.

The line begins just beneath the shelter of the overhanging lateral edge of the sucking disk, at the vertical of the 13th lamella from the front, close above the insertion of the pectoral. It rises in a gentle curve, keeping parallel with the curving posterior end of the disk, and then, as gently, and in a long, even curve, slopes down to a level with the mid-side. This descending curve is so gradual that it does not straighten out until at the vertical of the origins of the soft dorsal and the anal fins. From here it extends straight backward, exactly bisecting the peduncle, and out to the very tail tip, ending in a long, colorless tube with slight openings here and there, its open end only 1.5 mm. from the tips of the central caudal rays.

In the 15 mm. shark-sucker the lateral line is also conspicuous but of course not nearly so deeply stained as in the more adult

specimen. It shows as a continuous line beneath the surface. The contour is different from that in the adult, there being no anterior rise, but the line dropping down in a long, rather straight descent from its origin above the pectoral, to the mid-line of the body. It is traceable only to the base of the caudal and not distinguishable along the rays.

FINS

The relative ontological changes in length of the disk and of the base of the soft dorsal and anal fins are best shown by the direct comparison of their percentages. In the 15 mm. *Remora* the length of the soft dorsal is 72 per cent. of the disk length, whereas in the larger, 88 mm. fish, the former has equalled and surpassed the disk by a third, measuring 133 per cent. The same is true of the anal fin length, this being 78 per cent. of the disk length in the young, and 142 per cent. in the older fish.

In both there are 18 transverse lamellae in the first dorsal or cephalic sucking disk. The soft dorsal count is 25½ in the small remora and 24½ in the larger. The first few rays increase rapidly in length, reaching greatest height at the 6th in the smaller and at the 8th in the larger, then shortening and rising gradually to the last, which is relatively twice as long in the 15 mm. fish as in the other. All the anterior dorsal and anal rays show a slight branching at the tip and a distinct segmentation, differing thus in no particular from the succeeding rays.

The anal count is 22 in the young and 23½ in the older fish. The pectorals are broad and rounded, with I, 20 in the young fish and I, 26 in the larger The spines are very strong and as prominent as are those of the ventrals, whose count is, of course, I, 5.

As regards the position of the pectoral fins, the small *Remora* shows a depth of body at the pectorals of only 37 per cent. of the larger. The position percentages of these fins can be compared directly with one another:

15's depth at pectoral compared with 88's—37 per cent.
15's distance from dorsal surface to pectoral, to 88's—50 per cent.
15's distance from pectoral to ventral surface, to 88's—50 per cent.
15's vertical base length of pectoral compared with 88's—25 per cent.

So the relative dorso-ventral position is changed hardly at all in the two, the shift in measurements being due to the great relative

increase in the vertical extent of the base of the fin itself, from less than a third to almost one-half of the entire body depth.

The ontological changes in length of the paired fins offer great contrasts; in the half-inch *Remora,* in comparison with the head length, the pectoral length is 38 per cent., and that of the ventrals 24 per cent. In the 88 mm. fish both are exactly the same length, the ventrals having caught up with the pectorals, an increase of over half, or 54 per cent. of the length of the head.

The ventrals are quite free in the post-larva, indicating better natatory ability than in the older individual. In the latter the spine measures 12.8 mm., and the inner or 5th ray is 8.5 mm. long, and for exactly two-thirds of this length the ray is bound tightly, goby-like, to the skin beneath.

The outer, functional caudal rays in the small *Remora* are longer than the central ones, but that is all that can be said of the shape. The 88 mm. fish has a slightly emarginate or shallowly forked tail, the inward slope being almost straight. The count is:

15 mm. – (9)9 + 8(8)
88 mm. – (13)9 + 8(12)

The most striking thing about the tail in the larger fish is the fact that all the functional caudal rays, except the central two, are split vertically and sprung widely apart at the tips for a distance of 5 mm. This is independent of the usual distal branching of these rays. It is very slightly noticeable in the small specimen. The tips of the two central rays which bound the end of the lateral line, are normal and the tips strong and unsplit. In the case of several hundred species of deep sea and shore fish which have been cleared and stained by an identical process, this splitting has occurred only in this species. While it may very possibly have no important significance whatever, yet is it worthy of note that the cephalic disk was probably originally formed by the lateral splitting of the rays of the first dorsal fin.

General Proportion of Growth

In the case of six measurements I am able to compare fish of four ages:

A—is my 15 mm. Remora.

B—is a Remora taken at sea 35 miles southeast of Beaufort, North Carolina (Gudger, 1926).
C—is a fish which I collected at Key West (Gudger, 1926).
D—is my 88 mm. Remora.

The measurements are the times contained in the standard length and show an almost uniform progression:

	A	B	C	D
Total length	17.6 mm.	30 mm.	49 mm.	105 mm.
Standard length	15 mm.	27 mm.	43 mm.	88 mm.
Disk length	3.88	3	2.96	2.8
Disk width	16.5	6.75	7.17	5.6
Head width (at base of P)	8	6.75	5.7	5.2
Head length	4.3	3.6	3.5	3.3
Length base of soft dorsal	2.7	2.8	3.4	3.7
Length base of anal	3	3.18	3.58	4

Relative measurements between my two fish are as follows:

Standard length	15 mm.	88 mm.	17 per cent. of 15 to 88 mm. fish.
Depth (in length)	1.6 (9.3)	11.5 (7.6)	14 per cent. of 15 to 88 mm. fish.
Head (in length)	3.48 (4.3)	23.5 (3.3)	14.8 per cent. of 15 to 88 mm. fish.
Eye (in head)	.91 (3.8)	4.5 (5.2)	20 per cent. of 15 to 88 mm. fish.
Snout (in head)	1.18 (2.9)	11.5 (2)	10.2 per cent. of 15 to 88 mm. fish.
Maxillary (in head)	1.67 (2)	11 (2.14)	15.2 per cent. of 15 to 88 mm. fish.

NOMENCLATURAL NOTES ON THE SHORE FISHES OF BERMUDA[1]

BY WILLIAM BEEBE

AND

JOHN TEE-VAN

(Fig. 38)

SYSTEMATIC TABLE OF CONTENTS

[1] Contribution, New York Zoological Society, Department of Tropical Research, No 409

Introduction

While preparing a Field Book of the Shore Fishes of Bermuda[2] it became evident that a number of changes would have to be made in the list of species as recorded in the literature of Bermuda. As it is undesirable to include the discussions involving these species in the Field Book, the following pages summarize the changes suggested and made by us. These alterations, such as the elimination of species based upon questionable records, synonymizing of species by reason of new knowledge of their life histories and color phases, corrections of misidentifications, etc., are the result of four seasons' work in the field at Bermuda. This has been carried on in the course of the Oceanographic Expeditions of the Department of Tropical Research of the New York Zoological Society, at Nonsuch and at the Biological Station for Research. This field work has been coupled with the examination and comparison of Bermuda and West Indian materials, types and otherwise, in our own collections, in the Field Museum at Chicago, the Museum of Comparative Zoology at Cambridge, the United States National Museum at Washington and the American Museum at New York.

No attempt has been made at complete synonomy, but only pertinent Bermuda references are included.

Family CLUPEIDAE

Sardinella anchovia Cuvier and Valenciennes

Sardinella anchovia Cuvier and Valenciennes.

Sardinella anchovia Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XX, 1847, *p.* 269. Bean, *Field Col. Mus., Zool. Ser.*, VII, *No.* 2, *p.* 34.

Sardinella pinnula Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 122.

The types of *pinnula* in the U. S. Nat. Mus., the Bermuda specimens that Bean recorded as *anchovia*, a number of Bermuda specimens taken by us, and a specimen of *anchovia* fron Long Island have been examined by us. We can find no reason for not calling them all *anchovia*.

In the revision of *Sardinella* by Regan (1917), *pinnula*, described in 1912, was overlooked, but a specimen of *aurita*, under which *anchovia* was synonymized, was recorded from Bermuda. All of the Bermuda specimens agree with each other and disagree with Regan's definition in lacking a black opercular spot, which seems to be the only character separating *pinnula* from *anchovia*. However, in this connection it is of interest to note that in the Long Island

[2] Field Book of the Shore Fishes of Bermuda, by William Beebe and John Tee-Van, published under the auspices of the New York Zoological Society by G. P. Putnams Sons, 1933.

specimen and in some of our Bermuda fish, there is an appearance of a dusky spot caused by the dark gill cavity being viewed through a small transparent portion of the opercle. In the figure given by Cuvier and Valenciennes of *aurita* there is no dark opercular spot, although the dark projecting gill-filaments might be mistaken for one. The latter authors expressly state that there is a black opercular spot in *anchovia* and *aurita*.

Harengula macrophthalmus (Ranzani)

Harengula macrophthalmus (Ranzani).

Clupea macrophthalmus Ranzani, *Nov. Comm. Acad. Sci. Bonon.*, V, 1842, *p.* 320.

Sardinella macrophthalmus Bean, *Field Col. Mus., Zool. Ser.*, VII, *No.* 2, 1906, *p.* 34.

Harengula maculosa (not of Cuvier and Valenciennes) Regan, *Ann. Mag. Nat. Hist.*, (8) XIX, 377–395.

We prefer the treatment accorded to the genus *Harengula* by American authors, as opposed to Regan's revision of the group. Accordingly we retain *sardina* as a valid species, and the Bermuda specimen assigned to *maculosa* by Regan is placed under *macrophthalmus.*

Family DUSSUMIERIIDAE

Jenkinsia lamprotaenia (Gosse)

Jenkinsia lamprotaenia (Gosse).

Clupea lamprotaenia Gosse, *Nat. Sojourn in Jamaica*, 1851, *p.* 291, *pl.* 1, *fig.* 2.

Dussumieria stolifera Jordan and Gilbert, *Proc. U. S. Nat. Mus.*, VII, 1884, *p.* 25.

Stolephorus viridis Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 122.

Jenkinsia lamprotaenia, Beebe and Tee-Van, *Zoologica*, Vol. X, *No.* 1, 1928, *p.* 43.

The types of *Stolephorus viridis* Bean were examined, and as already stated by Nichols, they are *Jenkinsia lamprotaenia.*

Jenkinsia stolifera has also been placed under the synonomy of this species by the present authors (l. c.).

Family ENGRAULIDAE

Anchoviella choerostoma (Goode)

Anchoviella choerostoma (Goode).

Engraulis choerostoma Goode, *Amer. Journ. Sci. Arts*, Aug. 1874, *p.* 125.

Anchoviella choerostoma var. *atlantica* Borodin, *Bull. Vand. Oceano. Mus.*, I, *Art.* 1, 1928, *p.* 7.

The characters upon which the variety *atlantica* were established are certainly not valid. In the account of *choerostoma* given by Jordan and Seale

in their "Review of the Engraulidae" (Bull. Mus. Comp. Zool. Cambridge, LXVIII, No. 11, p. 404) the range of variation easily includes the characters of *atlantica*. In addition Borodin assumed that *choerostoma* was from the Pacific and that it had not been reported from Atlantic Panama. The species was originally described from Bermuda and has since been reported from various West Indian islands as well as from the Atlantic coast of Panama.

Family OPHICHTHYIDAE

Ophichthus havannensis (Bloch and Schneider)

Ophichthus havannensis (Bloch and Schneider).

Muraena havannensis Bloch and Schneider, *Syst. Ichth.*, 1801, *p.* 491.

Ophichthus triserialis (not of Kaup) Goode, *Am. Journ. Sci. Arts.*, XIV, Oct., 1877, *p.* 293; Bean, *Field Col. Mus., Zool. Ser.*, VII, *No.* 2, 1906, *p.* 31.

The Bermuda specimen upon which Goode's record was based, has been examined by us. We see no reason for referring it to the Pacific coast form as opposed to the Atlantic geminate species, and the specimen agrees well with the descriptions of *Ophichthus havannensis* as viewed in the light of recent knowledge of the species. The older descriptions specify uniserial teeth in the lower jaw for *havannensis* and biserial for *triserialis*. West Indian material, however, represented by Metzelaar's (1919) Curacao specimen, shows a slight overlapping of teeth anteriorly, so that for a short space there is a double row of teeth in the lower jaw. This condition is also found in Goode's Bermuda specimen. Goode evidently adhered strictly to the then existing definitions, resulting in the assignment of the Bermuda fish to a Pacific form.

Sphagebranchus ophioneus Evermann and Marsh

Sphagebranchus ophioneus Evermann and Marsh 1900.

Sphagebranchus ophioneus Evermann and Marsh, *Bull. U. S. Fish Comm.*, XX, 1900, *p.* 73, *fig.* 7.

Sphagebranchus anguiformis (not of Peters), Barbour, *Bull. Mus. Comp. Zool.*, XLVI, *No.* 7 1905, *p.* 112.

The young specimen (107 mm.) listed under *anguiformis* by Barbour has been examined. From its proportions (Head 11.2 in length, 3.2 in trunk; head and trunk 2.75 in length) and other characters, it is closer to *S. ophioneus* than to *anguiformis*, and as we have taken a much larger specimen of the former, it is undoubtedly that species. There is a note by Seale in the bottle containing the Barbour specimen, listing his disagreements with the identification.

Family MURAENIDAE

Enchelycore brunneus (Nichols)

Enchelycore brunneus (Nichols).

Gymnothorax brunneus Nichols, *Proc. Biol. Soc. Wash.*, XXXIII, 1920, *p.* 59.

Examination of the type of this species shows that it belongs to the genus *Enchelycore*, as it possesses the slit-like posterior nostril of that genus. It is probable that this species will later be shown to be the same as *Enchelycore nigrocastaneus* Cope, but we have had no material with which to compare the two forms.

The name *Gymnothorax brunneus* was also employed by Herre in 1923 for a Philippine eel (Philippine Journ. Sci., Manilla, P. I., 23, 1923, p. 212, fig. 13). We take pleasure in renaming the latter form **Gymnothorax herrei.**

Gymnothorax ocellatus Agassiz

Gymnothorax ocellatus Agassiz.

Gymnothorax ocellatus Agassiz, in Spix, *Pisc. Brasil.*, 1828, p. 91, *pl.* 50*b*.

?*Lycodontis jordani*, Evermann and Marsh, *Bull. U. S. Fish. Comm.*, XX, 1900, (1902), *pt.* 1, *p.* 78, *pl.* 2; Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, *p.* 32.

We have not examined specimens of either of the forms mentioned above. But in reviewing the original descriptions of the two species, it became evident that they are very close if not identical. When *jordani* was originally described, the serrations on the teeth were not noticed. Meek and Hildebrand in "The Marine Fishes of Panama," part I, p. 167, state of the single Panama specimen of *jordani* taken by them, "We have compared it with the type of the species with which it appears to agree quite well. The teeth were, however, erroneously described as being smooth, whereas they are distinctly serrate at least on posterior margin near the base. Its relationship therefore is with *G. ocellatus*."

G. ocellatus is a form with widely varying color variations, as can be witnessed by the number of names that have been erected for various specimens, and it is very probable that *jordani* is merely a xanthistic phase.

The four eels listed below are removed from the Bermuda faunal list. We have been unable to find the specimens to which they refer, and in all of the cases there are closely related species that have been found in Bermuda since the publication of the original record.

Leptocephalus sp.

Leptocephalus sp.

Leptocephalus sp., Goode, *Am. Journ. Art. Sci.*, XIV, 1877, *p.* 293.

This record is ignored as we have been unable to find the specimens and consequently to ascertain whether it represents a larval eel or a conger. The former are abundant off Bermuda, and a new species of Conger, *Conger harringtonensis*, has recently been described from Bermuda by Mowbray.

, sp. nov.

Ahlia sp. nov.

Ahlia sp. nov., Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 121.

We have been unable to find the specimen upon which this record is based. The record may possibly refer to either one of two West Indian species of *Myrophis* recently described by Parr and by Breder. These have been taken by us in Bermuda. The genera *Myrophis* and *Ahlia* have been synonymized by Parr.

Gymnothorax (resembling **verrilli**)

Gymnothorax (resembling *verrilli*).

Lycodontis (resembling *verrilli*) Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 121.

We have not been able to find the specimen referred to in this reference. The closely related *G. vicinus*, first recorded by Goode from Bermuda in 1877, but ignored by Bean in his check-list (1906) has been found by us in Bermuda, and this may be the form mentioned here by Bean.

Muraena sp. nov.

Muraena sp. nov.

Muraena sp. nov., Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 121.

We have not found the specimen upon which Bean established this record. It may possibly refer to the new species described in 1930 by Mowbray, *Muraena aureus*.

Family SYNODONTIDAE

Synodus foetens (Linnaeus)

Synodus foetens (Linnaeus).

Salmo foetens Linnaeus, *Syst. Nat.*, *Ed.* XII, 1766, *p.* 513.

Synodus lacerta (not of Risso) Goode, *Bull. U. S. Nat. Mus.*, V, 1876, *p.* 68.

Synodus saurus (not of Linnaeus) Barbour, *Bull. Mus. Comp. Zool.*, XLVI, No. 7, 1905, *p.* 113; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 35.

We have not been able to find the specimens upon which the Bermuda records of the European Lizardfish are based. Some of the recent studies of larger specimens of *foetens* taken along the coast of the United States show dimensions and proportions overlapping those of *saurus*.

Considering the lack of material and the peculiarities of distribution coincident with the admittance of a European shallow-water bottom-fish to the Bermuda fauna, it seems best to think that the specimens were identified as *lacerta* and *saurus* at a time when the variation in *foetens* was not sufficiently well-known.

Family HOLOCENTRIDAE

Holocentrus tortugae Jordan and Thompson

Holocentrus tortugae Jordan and Thompson.

Holocentrus tortugae Jordan and Thompson, *Bull. U. S. Bur. Fisheries*, XXIV, 1904 (1905), *p.* 236, *fig.* 1.

Holocentrus puncticulatus Barbour, *Bull. Mus. Comp. Zool., Cambridge*, XLVI, 1905, *p.* 117.

Holocentrus siccifer (not of Cope) Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 43.

According to the revision of the genus *Holocentrus* given by Parr (1930, p. 34) the specimen assigned to *siccifer* by Bean, must be placed under *tortugae*,—thus removing this problematical species from the Bermudian faunal lists. The dimensions given by Bean for his Bermuda specimen readily fall within the limits of *tortugae* as stated by Parr.

Holocentrus vexillarius (Poey)

Holocentrus vexillarius (Poey).

Holocentrum vexillarium Poey, *Memorias*, II, 1862, *p.* 158.

Holocentrus brachypterus Poey, *Repertorio*, I, 1866, *p.* 184; Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 121.

Field notes made in Bermuda confirm Parr's comments on the relationships of these forms.

Family SYNGNATHIDAE

Corythoichthys ensenadae Silvester

Corythoichthys ensenadae Silvester.

Corythoichthys ensenadae Silvester, *Carn. Inst. Yearbook*, 14, 1915, *p.* 215; Mowbray, *Copeia*, 104, 1922, *p.* 19.

It is probable that this species belongs to the genus *Micrognathus* as understood by Duncker. However, the type of the species has disappeared from the collections of Princeton University and we have been unable to trace it, so that the proof of this conjecture must await examination of further material.

Hippocampus punctulatus Guichenot

Hippocampus punctulatus Guichenot.

Hippocampus punctulatus Guichenot, in Ramon de la Sagra, *Hist. Ile. Cuba, Poiss.*, 1853, 174, *pl.* 5, *fig.* 2; Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, *p.* 40.

Hippocampus antiquorum (not of Leach) Goode, *Am. Journ. Sci. Arts*, XIV, Oct. 1877, *p.* 291.

Hippocampus hippocampus (not of Linnaeus) Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, *p.* 40.

Hippocampus brunneus Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 32; Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, *p.* 39, *fig.* 1.

Hippocampus hudsonius (not of DeKay) Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, *p.* 40.

Hippocampus stylifer (not of Jordan and Gilbert) Bean, *Field Col. Mus.*, Vol. VII, 1906, No. 2, *p.* 40.

? *Hippocampus kinkaidi* Townsend and Barbour, *Bull. N. Y. Zool. Soc.*, No. 23, 1906, *p.* 304, *fig.*

We have a considerable number of Bermuda seahorses in our collections and we have also examined all the specimens taken and reported upon by Bean with the exception of the type of *brunneus*. We are of the opinion that all of these Bermuda fish, as explained below,—Bean's *hudsonius*, *punctulatus*, *brunneus* and *stylifer*, are the same, and that the name *punctulatus* Guichenot seems to be the best one to apply to the Bermuda seahorse. *Hippocampus kinkaidi*, described by Townsend and Barbour from Bermuda, is a questionable form. Its status is uncertain and for that reason we place it beneath *punctulatus* with a question. Under any circumstances, the need for a revision of the West Indian seahorses is apparent.

The Bermuda seahorses examined by us divide into two markedly different groups, the first with few spines and very few dermal filaments, the second group markedly spinose and with many filaments. The first group are all males and the second group females. There is considerable variation in depth of body but we have been unable to correlate this with any other factors. As far as coloration, which is admittedly a character of little if any value in this group, is concerned, the preserved specimens give no hint of species differentiation. The color of the living fish in the field is practically any color that happens to surround the fish.

The dorsal fin count in the Bermuda fish varies from 17 to 20, the fin being situated on 2 or 2½ body plus 1 or ½ caudal segments.

Modern authors, such as Jordan and Evermann, Bean 1906, etc., have distinguished *punctulatus* from *hudsonius* mainly on the possession of 17 to 18 rays in the dorsal fin of the former and of 19 in the latter. This has been done despite the fact that Guichenot in the original description of *punctulatus* listed 22 dorsal rays and showed 21 in his figure.

In reviewing the various specimens the following notes were made:—

The large specimen called *hudsonius* by Bean (Field Mus. No. 5064) does not differ from the specimen called *punctulatus* by him, except for the extra dorsal ray. The small fish identified by Bean as *hudsonius* is a female and does not differ from similar specimens identified as *punctulatus*.

The specimen called *stylifer* by Bean possesses 18 dorsal rays and is similar to the others in other ways. The dorsal fin is damaged, but there is no difficulty in tracing the rays with a binocular microscope. As *stylifer* has been reported as a species with 16 rays only in the dorsal fin, and as we believe the fin, because of its damaged condition, to have been wrongly counted, we see no reason for retaining this form as a valid Bermuda species.

Hippocampus brunneus Bean 1906, originally described from Bermuda, has already been included as a nominal color form of *punctulatus* by Fowler (1915, p. 446), and we agree with this decision.

Hippocampus kinkaidi is similar to some of our smaller fish, although its armature is slightly different. We have not examined the type specimen. Considering the variation within the Bermuda seahorses, we are temporarily including it under *punctulatus*.

The following table, showing Bean's specimens and a selection of specimens from the Bermuda Oceanographic Expedition, plus the description of *kinkaidi* will tend to show the similarities of the various fish:

Specimen Number	Sex.	Length, from post. margin of coronet to tip of tail. mm.	Length of Head,* mm.	Snout in head.	Eye in Head.	Post-orbital Head in Head.	Depth in Head.	Body Segments	Caudal Segments.	Dorsal		
										Fin Rays.	on Body Segments.	on Tail Segments.
brunneus, type, Field Mus. 5494	♂			2.5	6	2 5	1 33	11	35	18	3,–2½ in fig.	1
Bermuda Ocean. Exped. No. 9321.	♂	63	12,7	2.6	5 2	2.3	1.4	12	35	20	2½	1
Bermuda Ocean. Exped. No. 9143.	♂	86	19.2	2 7	5 6	2 3	1 2	12	33	18	2½	½
Field Museum. No. 5064.	♂	88	19 8	2 7	5 6	2.3	1.15	12	34	19	2	1
Field Museum. No. 5495.	♂	126	25	2 5	5 5	2.2	1 1	12	35	18	2	1
kinkaidi, type description.	♀	1.5 in. long	?	2 5	6	2 5	2 ?	12	?	19	3, -2½ in fig.	1
Bermuda Ocean. Exped. No. 8897	♀	41	11	2 7	5	2 7	1 9	12	35	18	2	1
Bermuda Ocean. Exped. No 9271.	♀	59	13	2 6	5 2	2.5	1 7	12	34	?	2	1
Field Museum. No. 5066	♀	62	14 3	2 4	5 8	2 4	1 6	12	33	18	2½	1
Field Museum No. 5065.	♀	64	14 7	2 45	5 5	2.45	1.6	12	35	19	2	1
Bermuda Ocean. Exped. No. 8878.	♀	69	16 5	2 54	5.9	2 1	1 4	12	35	18	3	1
Bermuda Ocean. Exped. No. 8908.	♀	89	20 5	2 2	5 8	2.4	1.2	12	35	19	2	1
Bermuda Ocean. Exped. No. 9094.	♀	98	24	2.3	6	2.3	1.5	12	35	18	2	1

* Measured from snout to gill-opening.

Family FISTULARIIDAE

Fistularia tabacaria Linnaeus

Fistularia tabacaria Linnaeus.

Fistularia tabacaria Linnaeus, *Syst. Nat., ed.* X, 1758, *p.* 312.

Fistularia petimba Günther, *Challenger Exped. Rep., Shore Fishes, p.* 68; Meek and Hildebrand, *Field Mus. Nat. Hist., Zool. Ser.,* XV, *Part* 1, 1923, *p.* 252.

We consider *petimba* as here stated to be the same as *tabacaria*, following Fowler (Proc. Acad. Nat. Sci. Phila., 1921, p. 439). Bean, although the Bermuda record existed before his 1906 check-list was published, evidently thought the same, as he did not include the species in his report.

Family ATHERINIDAE

Atherina harringtonensis Goode

Atherina harringtonensis Goode.

Atherina harringtonensis Goode, *Am. Journ. Sci. Arts., 3rd ser.*, XIV, No. 82, 1877, *p.* 297.

Menidia menidia (not of Linnaeus) Barbour, *Bull. Mus. Comp. Zool., Cambridge*, XLVI, 1905, No. 7, *p.* 116.

We have examined specimens taken in Bermuda by Barbour and labelled *Menidia menidia*, and presumably the specimens upon which the above record is based. These fish are *Atherina harringtonensis*, and this identification is borne out by Barbour's note that they were exceedingly common, which is certainly true of *harringtonensis* in Bermuda. In addition to this fact Barbour did not record *Atherina harringtonensis*. We have seen no specimens of *Menidia* in our four years in Bermuda.

Family MUGILIDAE

Mugil curema Cuvier and Valenciennes

Mugil curema Cuvier and Valenciennes.

Mugil curema Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XI, 1836, *p.* 64 (87).

Mugil trichodon (not of Poey) Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, 1906, *p.* 41.

We have examined four of the series of specimens called *M. trichodon* by Bean (Field Mus. Nos. 5210 (2), 5213 and 5215). These fish possess eight anal rays, but in all other characters agree with *Mugil curema*. This combination of characters is present in many of our own fish. However, the Bean specimens labelled *trichodon*, have 36 to 38 scales from the shoulder to the hypural, plus one or two on the base of the caudal fin, while *trichodon*, according to specimens and descriptions, is a large scaled species with from 29 to 31 scales in the lateral line.

These records of *trichodon* therefore, ought to be changed to *Mugil curema*, and the current descriptions of the latter species altered to allow variation of one ray in the anal fin, the descriptions thus reading Anal III, 8 or 9. This variation has been recognized previously by Jacot (1920).

Examination of specimens in collections has shown that too much dependence has been placed in species determination of mullets, upon the anal fin ray count,—almost any mullet in the West Indian fauna possessing 8 anal rays has been placed in *trichodon*.

True *Mugil trichodon* exists in Bermuda as we have specimens in our collections.

Family STROMATEIDAE?

Eucrotus ventralis Bean

Eucrotus ventralis Bean.

Eucrotus ventralis Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 123.

The type of this pelagic species, recorded as being in the Bermuda Museum of Natural History, is now in the collection of the American Museum of Natural History, New York City.

Family CARANGIDAE

Decapterus punctatus (Agassiz)

Decapterus punctatus (Agassiz).

Caranx punctatus Agassiz, in Spix, *Pisc. Brasil,* 1829, *p.* 108, *pl.* 56*a*.

Decapterus punctatus Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2. *p.* 48.

Decapterus scombrinus (not of Valenciennes) Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 48.

We consider the two specimens referred to by Bean as *D. scombrinus* to be variants of *punctatus*. Bean, in his own account, also questioned these fish, as he says,—"These two examples are referred to *D. scombrinus*, although it is doubtful if this species be distinct from *punctatus*."

Decapterus macarellus (Cuvier and Valenciennes)

Decapterus macarellus (Cuvier and Valenciennes).

Caranx macarellus Cuvier and Valenciennes, *Hist. Nat. Poiss.*, IX, 1833, *p.* 33 (40).

Decapterus macarellus, Parr, *Bull. Bingham Oceano. Coll.*, Vol. III, *Art.* 4, 1930, *p.* 46.

Decapterus sanctae-helenae (not of Cuvier and Valenciennes) Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 121.

We follow Parr in referring the western Atlantic specimens of *sanctae-helenae* to *macarellus*.

Caranx crysos (Mitchill)

Caranx crysos (Mitchill).

Scomber crysos Mitchill, *Trans. Lit. Phil. Soc. N. Y.*, I, 1815, *p.* 424.

Caranx caballus, Gunther, *Rep. Shore Fish Challenger Expedition,* 1880, 10; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 48.

We include the Challenger Bermuda record of *caballus* in the synonomy of *crysos*. The specimen upon which it is based cannot be found in the British Museum.

Family SERIOLIDAE

Seriola dumerili (Risso)

Seriola dumerili (Risso).

Caranx dumerili Risso, *Ichthy. Nice,* 1810, 175, *pl.* 6, *fig.* 20.

Seriola lalandi Cuvier and Valenciennes, *Hist. Nat. Poiss.*, IX, 1833, 155 (208); Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 48.

Following Meek and Hildebrand (Marine Fishes of Panama, p. 397) we consider *lalandi* as a synonym of *dumerili*. However, the status of the fishes of the genera *Seriola* and *Zonichthys* is quite confusing, and the entire group is in urgent need of careful study.

Family APOGONIDAE

Apogon sellicauda Evermann and Marsh

Apogon sellicauda Evermann and Marsh 1900.

Apogon sellicauda Evermann and Marsh, *Bull. U. S. Fish. Comm.*, XX, 1900, *p.* 143, *fig.* 40.

Apogon imberbis (not of Linnaeus), Goode, *Am. Journ. Sci. Arts*, XIV, *Oct.* 1877, *p.* 292; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 51.

Two Bermuda specimens from the U. S. National Museum collection (Nos. 21,957 and 22,172), one from J. M. Jones and the other from the Mus. West. Univ., have been examined by us. They are labelled *Apogon imberbis*, and presumably are the specimens upon which Goode's identification is based. Goode had considerable Bermuda material from J. M. Jones, and the Jones' specimen bears a number post-dating the second fish, so the probability is that these are the two fish which Dr. Goode identified. Both are deep brown and straw color, having lost all trace of pattern and color. The smaller specimen has been dried at some time and is considerably shrivelled.

The larger of the two fish, 70 mm. standard length (No. 21,957), we identify as *Apogon sellicauda* Evermann and Marsh, of which species we have numerous Bermuda examples.

Until the issuance of Evermann and Marsh's "Fishes of Porto Rico," all of the known West Indian species of *Apogon* possessed relatively large scales, 23 to 26 pores in the lateral line. Probably because of this fact, Dr. Goode considered that the fish mentioned above with 29 lateral line pores was closer to *imberbis*, the Mediterranean Cardinal-fish with 28 to 30 lateral line scales, than any form then known. This was quite consistent with his views as to the European origin of other Bermuda fishes.

However, Evermann and Marsh in their description of *sellicauda* recognized the existence of a small-scaled West Indian form, mentioning 27 scales in the lateral line in the original account of the species. Material subsequently taken shows that the variation in the scale count is from 27 to 29,—counts which include Goode's specimen.

Apogon sellicauda has been synonymized with *A. maculatus* by Metzelaar (1919, p. 59) on the basis of color, and in this he has been followed by Breder (1927, p. 38). However, it seems better to keep the two forms separate until it has been shown that the difference in scale count is of no specific value. As far as color is concerned, while the two forms are exceedingly close, it has not been demonstrated that *maculatus* possesses the conspicuous and large black saddle on the caudal peduncle, nor the coloration of the head and eye of *sellicauda*.

The smaller of the two U. S. National Museum specimens (No. 22,172) belongs to the large-scaled group of West Indian Apogons (approximately 28 pores in the lateral line). While it is definitely not *A. imberbis*, it is in such poor condition that we hesitate giving it a definite name.

Apogon pigmentarius (Poey)

Apogon pigmentarius (Poey).

Monoprion pigmentarius Poey, *Memorias*, II, 1861, *p.* 123.

This species exists in Bermuda as we have found specimens. The specimens recorded under this name by Bean (Field Col. Mus., Zool. Ser., Vol. VII, No. 2, p. 50) have been examined by us. These fish are *Astrapogon stellatus* (Cope), as can be verified by reading Dr. Bean's notes.

Astrapogon stellatus (Cope)

Astrapogon stellatus (Cope).

Apogonichthys stellatus Cope, *Trans. Amer. Phil. Soc.*, XIII, 1869, *p.* 400.

Astrapogon stellatus Fowler, *Proc. Acad. Nat. Sci., Phila.*, LXIII, 1906, *p.* 527.

Apogon pigmentarius (not of Poey) Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 50.

This species is a common Bermuda form. Bean's fish listed as *Apogon pigmentarius*, belong under this species as stated above,—his specimens possessing the elongate pelvic fins characteristic of this species.

Astrapogon stellatus with its exceptionally long pelvic fins is conspicuously different from its relatives in the genus *Apogonichthys*, and for that reason we prefer to use Fowler's generic name of *Astrapogon*. The following key can be used to differentiate the West Indian genera *Apogon, Apogonichthys* and *Astrapogon:*—

A. Caudal moderately forked .*Apogon*

AA. Caudal rounded.

B. Pelvic fins short, the tips of the fins not or barely reaching to the origin of the anal fin *Apogonichthys*

BB. Pelvic fins long, their tips reaching far beyond the origin of the anal fin .*Astrapogon*

Family SERRANIDAE

Anthias louisi Bean

Anthias louisi Bean.

Anthias louisi Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 124.

The type of this species, recorded as being in the Bermuda Museum of Natural History, is now in the collection of the American Museum of Natural History, New York City.

Family LUTIANIDAE

Lutianus buccanella (Cuvier and Valenciennes)

Lutianus buccanella (Cuvier and Valenciennes).

Mesoprion buccanella Cuvier and Valenciennes, *Hist. Nat. Poiss.*, II, 1828, 344 (455).

Lutianus aya (not of Bloch) Goode, *Bull. U. S. Nat. Mus.*, V, 1876, *p.* 55; Goode, *Am. Journ. Sci. Arts*, XIV, Oct. 1877, *p.* 292; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 57.

Goode's record of *aya* must belong to this species as he reports a black spot at the base of the pectoral fin, and *buccanella* is the only red Bermudian snapper to which this characteristic could refer. Ginsburg (1930, p. 276) in his paper on red snappers, is also in agreement with this statement. As far as the presence of *aya* in Bermuda is concerned, Bean (1906, p. 57) states that "There is no evidence that *aya* occurs in Bermuda." Our experiences during four years in Bermuda causes us to agree with this statement.

Mowbray (Copeia, No. 108, 1922, p. 49) records *aya* from Bermuda. But considering the status of our present knowledge of the various red West Indian and Bermuda snappers, it seems best to question this record until more detailed material is produced.

Goode's account of *aya* is an extremely interesting one as he confused three separate species and gave them all the name of a fish that did not live in Bermuda. Thus his red snapper, *aya*, refers to *buccanella*, his common name of Yelting refers to the Yellow-tail (*Ocyurus chrysurus*), and the name of Glass-eyed Snapper to *Etelis oculatus*.

Family HAEMULIDAE

Bathystoma aurolineatum (Cuvier and Valenciennes)

Bathystoma aurolineatum (Cuvier and Valenciennes).

Haemulon aurolineatum Cuvier and Valenciennes, *Hist. Nat. Poiss.*, V, 1830, *p.* 176 (237).

Bathystoma aurolineatum, Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 58.

Bathystoma rimator (not of Jordan and Swain) Barbour, *Bull. Mus. Comp. Zool.* XLVI, No. 7, 1905, *p.* 123; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 58.

We have examined the specimens called *rimator* by Barbour (M. C. Z. 32843). The depth of the body in these fish averages 3.2 to 3.45.

As we understand the differences, judging from the literature, between *rimator* and *aurolineatum*, the former species is a deeper form, the depth being from 2.75 to 3 in the length, while in *aurolineatum* the same measurement is from 3.1 to 3.7. This, in addition to the verfication of other characters, would make the specimens mentioned above *aurolineatum*, and we so consider them.

Bathystoma aurolineatum is common in Bermuda, and we have had dozens of specimens, all of which have agreed with our ideas as to the limits of the species. We have never found specimens of *rimator*.

Under any circumstances the genus *Bathystoma* is in urgent need of careful study.

Family SPARIDAE

Diplodus argenteus (Cuvier and Valenciennes)

Diplodus argenteus (Cuvier and Valenciennes).

Sargus argenteus Cuvier and Valenciennes, *Hist. Nat. Poiss.*, VI, 1833, 44 (60).

Sargus variegatus (not of Lacepede) Goode, *Bull. U. S. Nat. Mus.*, 5, 1876, *p.* 52 (account confused with that of *Pimelepterus bosci*).

Diplodus holbrooki (not of Bean) Fowler, *Proc. Acad. Nat. Sci. Phila.*, LXXXI, 1930, 644.

The common Bream of Bermuda is considered by us as *argenteus*, the American form of the genus, rather than as *Sargus sargus* or *S. variegatus* as Dr. Goode recorded it. Dr. Bean (1906) evidently had the same opinion as he ignored the name of the European form in his check-list of Bermuda fishes.

The specimen identified by Fowler as *Diplodus holbrooki* from Bermuda, has been examined and compared with Bermuda Breams. We find no reason for considering it as otherwise than *argenteus*. The specimen is damaged so that exact scale counts are somewhat difficult, but it definitely possesses the smaller scales of *argenteus* as opposed to those of *holbrooki*.

Family GERRIDAE

Eucinostomus californiensis (Gill)

Eucinostomus californiensis (Gill).

Diapterus californiensis Gill, *Proc. Acad. Nat. Sci. Phila.*, XIV, 1862, *p.* 245.

Eucinostomus pseudo-gula Poey, *Enumeratio*, 1875, *p.* 53, *pl.* 1.

Eucinostomus pseudogula Bean, *Field, Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 60.

Eucinostomus harengulus Goode and Bean, *Proc. U. S. Nat. Mus.*, II, 1879, *p.* 132; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 59.

We follow Meek and Hildebrand (Marine Fishes of Panama, pp. 584–586) in placing *pseudogula* and *harengulus* under *californiensis*. Nichols (1929, p. 183) does not agree with this, and it is possible that further study will show that the Atlantic and Pacific forms ought to be separated.

It is of interest to note that our Bermuda specimens of *Eucinostomus gula* and *californiensis* are quite uniform in proportions and counts. The condition of overlapping of one species toward the other, stated by Meek and Hildebrand (582–584) and by Beebe and Tee-Van (1928, p. 167) and found respectively in Panama and Haiti, does not occur in the Bermudian specimens seen by us.

Family CHAETODONTIDAE

Chaetodon ocellatus Bloch

Chaetodon ocellatus Bloch.

Chaetodon ocellatus Bloch, *Naturgesch. Ausl. Fische,* III, *pl.* 211, 1787, 105 (Also from the East Indies); Barbour, *Bull. Mus. Comp. Zool.,* XLVI, No. 7, *p.* 127.

Chaetodon ataeniatus (not of Poey), Bean, *Field Col. Mus., Zool. Ser.,* VII, No. 2, *p.* 73.

We have examined the specimens listed as *ataeniatus* by Bean, and we can see no reason why they should not be considered as *ocellatus.*

Angelichthys bermudensis (Goode)

Angelichthys bermudensis (Goode).

Holacanthus ciliaris var. *Bermudensis* Goode, *Bull. U. S. Nat. Mus.,* 5, 1876, *p.* 43.

Angelichthys isabelitae Jordan and Rutter, in Jord. and Evermann, *Fishes N. and Middle America,* 1898, *p.* 1685.

Angelichthys ciliaris (not of Linnaeus) Barbour, *Bull. Mus. Comp. Zool.,* XLVI, No. 7, 1905, *p.* 127; Bean, *Field Col. Mus., Zool. Ser.,* VII, No. 2, 1906, *p.* 74.

Angelichthys formosus Bean, *Field Col. Mus., Zool. Ser.,* VII, No. 2, 1906, *p.* 74.

Goode in 1876 in his "Catalogue of the Fishes of the Bermudas," gives a color description of a specimen of the common angelfish of Bermuda, listing it under *Holacanthus ciliaris* (Linne) Lacépède. After the color description he gives the following notes, "My specimens, some twelve in number, differ from all descriptions in the absence of the spot of brown, encircled with blue, on the nape. I have examined numerous West Indian specimens and find it universally present. Should this character prove constant, the Bermuda Angel-fish may be considered a geographical variety, *Holacanthus ciliaris,* var. *Bermudensis.*"

Goode's descriptions and notes agree with the species currently known as *Angelichthys isabelitae,* which is the common angelfish of Bermuda, and it is evident that the latter name must be replaced by *bermudensis* Goode.

The specimens listed by Barbour, and those listed by Bean under *ciliaris* and *formosus* have been examined by us. They are all specimens of *bermudemsis,* the specimen listed under *formosus* being a young fish.

Family POMACENTRIDAE

Demoisellea marginatus (Castelnau)

Demoisellea marginatus (Castelnau).

Heliases marginatus Castelnau, *Anim. Amer. Sud., Poiss.,* V, 1830, 370 (394).

Furcaria cyanea (not of Poey) Barbour, *Bull. Mus. Comp. Zool., Cambr.,* XLVI, No. 7, *p.* 124; Bean, *Field Col. Mus., Zool. Ser.,* VII, 2, *p.* 63.

The Bermuda specimen recorded by Barbour as *Furcaria cyanea* has been examined and compared with the types of *cyanea* which are preserved in the Museum of Comparative Zoology. It differs from that species in posessing the low type of anal fin characteristic of *marginatus* and *multilineatus*,—differences pointed out by Beebe and Tee-Van (Zoologica, X, 1, pp. 192–194). In its other characters it also agrees with *marginatus*.

The label in the bottle containing the fish, states, "Honda ? Bermuda, Captain Hamilton 1864." We do not know where Honda is located, and since 1864 there is no additional record of the fish in Bermuda. It is possible that it may have been recorded from Bermuda by error.

Whitley (Rec. Austr. Mus., XVI, No. 6, p. 295) has pointed out that *Furcaria* Poey 1860 is preoccupied by *Furcaria* Lesson 1838, and proposes *Demoisellea* in place of Poey's name. This will cause the Bermuda fish of this group to stand as follows: *Demoisellea cyanea* (Poey), *Demoisellea marginatus* (Castelnau), and *Heliases bermudae* (Nichols).

Family CORIDAE

Iridio radiata (Linnaeus)

Iridio radiata (Linnaeus).

Labrus radiatus Linnaeus, *Syst. Nat.*, *Ed.* X, 1758, *p.* 65. *fig.* 6.
Iridio radiatus Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 68; Mowbray, *Fauna Bermudensis*, No. 1, 1931, *6th unnumbered page.*
Iridio elegans Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 30; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, 1906, *p.* 65, *fig.* 6.

Iridio elegans represents one of the immature stages of this species, a fact that has already been noted by Mowbray, and verified by us in a number of individuals.

The inclusion of *Iridio bivittatus* (Bloch) in the synonymy of this species is unwarranted. Both forms are quite distinct and the growth stages of *bivittatus* have been admirably demonstrated by Mowbray (Fauna Bermudensis, 6th unnumbered page).

Iridio maculipinna (Muller and Troschel)

Iridio maculipinna (Muller and Troschel).

Julis maculipinna, Muller and Troschel, in Schomburgk, *Hist. Barbados*, 1848, *p.* 674.
Iridio meyeri Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 29; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, 1906, *p.* 65, *fig.* 7.
Iridio microstomus Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 30; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 67, *fig.* 8.
Iridio maculipinna Bean, *Proc. Biol. Soc. Wash.*, XXV, 1912, *p.* 122.
Iridio frenatus Nichols, *Proc. Biol. Soc. Wash.*, XXXIII, 1920, *p.* 61.

All of the nominal forms mentioned above have been recorded at one time or another from Bermuda, and for a number of years our records of this species were listed under *meyeri*, which is locally quite common.

Recent comparison of these Bermuda specimens called *meyeri* with the older descriptions of *maculipinna* leave no doubt that the two are the same. The species is variable in coloration, but in all of its phases except those of the very young, it possesses dark transverse cross-bars on top of the head, plus a dark spot in the dorsal fin. The bands on top of the head persist through all of the older descriptions of *maculipinna* and they are described either as dark bands, or the interspaces are denoted as pale bands, the divergence being due to discoloration due to preservation.

We have had specimens of the nominal *microstomus* in the field and we consider it as the young of this species, although it lacks the characteristic head markings.

The type of *Iridio frenatus* has also been examined by us and it is a rather dark example of *maculipinna*.

Iridio garnoti (Cuvier and Valenciennes)

Iridio garnoti (Cuvier and Valenciennes).

Julis garnoti Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XIII, 1839, *p.* 285 (390).

Iridio decoratus Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 29; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 64, *fig.* 5.

Our studies in the field show quite conclusively that *decoratus* is but a nominal young form of *garnoti.*

Thalassoma bifasciatum (Bloch)

Thalassoma bifasciatum (Bloch).

Labrus bifasciatus Bloch, *Naturges. Ausl. Fische*, V, 1791, *p.* 131.

Julis nitida Günther, *Cat. Fish Brit. Mus.*, IV, 1862, *p.* 190.

Julis nitidissima Goode, *Am. Journ. Sci. Arts*, XIV, Oct. 1877, *p.* 293.

Chlorichthys bifasciatus Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, 1906, *p.* 68.

Chlorichthys nitidus Bean, *Field Col. Mus., Zool. Ser.*, Vol. VII, No. 2, 1906, *p.* 68.

Bermudichthys subfurcatus Nichols, *Proc. Biol. Soc. Wash.*, XXXIII, 1920, *p.* 62.

Thalassoma bifasciatus Breder, *Bull. Bingham Ocean. Coll.*, Vol. 1, No. 1, 1927, *p.* 60–63.

.*Thalassoma bifasciatum* Beebe and Tee-Van, *Zoologica*, Vol. X, No. 1, 1928, *pp.* 205–206; Tee-Van, *Bull. N. Y. Zool. Soc.*, XXXV, No. 2, 1932, *pp.* 43–47.

Thalassoma nitida Beebe and Tee-Van, *Zoologica*, Vol. X, No. 1, *pp.* 205–206.

Iridio cyanocephalus (not of Bloch) Barbour, *Bull. Mus. Comp. Zool.*, XLVI, No. 7, 1905, *p.* 125.

The synonymy of this species, as far as *T. bifasciatum* and *T. nitida* is concerned, has been proven quite conclusively by Breder (1927), Beebe and Tee-Van (1928) and Tee-Van (1932) (l. c.).

The type of *Bermudichthys subfurcatus* in the American Museum of Natural History, which we have examined, is a damaged specimen of this species. The apparent differences in fin ray counts do not exist when the specimen is examined under a binocular microscope, and in teeth and color it does not differ from similar dark specimens from Bermuda. We consider the tail as lunate, not forked.

A Bermuda specimen in the Barbour collection at the Museum of Comparative Zoology labelled *Iridio cyanocephalus*, and presumably that upon which the Barbour record is based, is an exceedingly dark specimen of the Blue-head, *Thalassoma bifasciatum*. Barbour used the common name Blue-head for his specimen, so that the change in record is also supported by that evidence. We have never found true *cyanocephalus* at Bermuda, so that the name can be expunged from Bermuda faunal lists.

Family SPARISOMIDAE

Cryptotomus roseus Cope

Cryptotomus roseus Cope.

Cryptotomus roseus Cope, *Trans. Amer. Phil. Soc.*, XIV, 1871, *p.* 462.
Cryptotomus crassiceps Bean, *Proc. Biol. Soc. Wash.*, XIX, 1906, *p.* 32; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, 1906, No. 2, *p.* 70.

We follow and agree with Fowler (1915, p. 257) in synonymizing the nominal color form *crassiceps* with *roseus*. Bermuda specimens taken by us are in accord with this merging.

Sparisoma radians (Cuvier and Valenciennes)

Sparisoma radians (Cuvier and Valenciennes).

Scarus radians Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XIV, 1839, *p.* 153 (206).
Sparisoma radians Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 72.
Scarus hoplomystax Cope, *Trans. Amer. Phil. Soc.*, XIV, 1871, *p.* 462.
Sparisoma hoplomystax Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 72.
Sparisoma xystrodon Jordan and Swain, *Proc. U. S. Nat. Mus.*, VII, 1884, *p.* 99; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 73.

We follow Meek and Hildebrand in synonymizing the above species. Bermuda specimens are in agreement with this merging.

Family GOBIIDAE

Rhinogobius mowbrayi Bean

Rhinogobius mowbrayi Bean.

Rhinogobius mowbrayi Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, 1906, No. 2, *p.* 81, *fig.* 12.
Leptophilypnus crocodilus Beebe and Tee-Van, *Zoologica*, Vol. X, 1928, No. 1, *p.* 219, *fig.*

The type of *Leptophilypnus crocodilus* Beebe and Tee-Van, has been compared with Bermuda specimens of *Rhinogobius mowbrayi*. They are undoubtedly the same, and the misidentification arose mainly because of the damaged ventral fins of the Haitian specimen, which produced an eleotrid-like appearance.

Lophogobius glaucofraenum (Gill)

Lophogobius glaucofraenum (Gill).

Coryphopterus glaucofraenum Gill, *Proc. Acad. Nat. Sci. Phila.*, 1863, *p.* 263 (Reported from the Coast of Washington,—the latter statement evidently an error).

Rhinogobius glaucofraenum Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, *p.* 81.

Gobius translucens Nichols, *Bull. Amer. Mus. Nat. Hist.*, XXXIV, 1915, *p.* 145, *fig.* 2; Nichols, *Proc. Biol. Soc. Wash.*, XXXIII, 1920, *p.* 63.

Lophogobius pallidus Parr, *Bull. Bingham Oceano. Coll.*, Vol. III, Art. 4, 1930, *p.* 122, *fig.* 33; Beebe and Tee-Van, *Zoologica*, Vol. XIII, No. 5, 1932, *p.* 120.

In recently examining specimens that had been assigned in the field at Bermuda to *glaucofraenum* and *translucens* a well-marked dermal crest was noticed. The crest is similar to that described and illustrated by Parr in his description of *Lophogobius pallidus*. These well-preserved Bermuda fish have been compared with the type of *translucens* with which they agree in form, pattern and in all other characters except that of the dorsal crest. The type of *translucens*, however, is somewhat shrivelled as far as the top of the head is concerned, and while the crest does not show, we believe that this is because of methods of preservation. It does, however, possess the conspicuous pigment spots that appear on the dermal ridges of the Bermuda specimens, and there is no doubt in our minds but that the type of *translucens* and the Bermuda specimens are the same.

Judging from Bermuda specimens there is no reason for maintaining *translucens* separate from *glaucofraenum*, as the difference in scale counts and color cause them to overlap. We have not been able to examine the types of *glaucofraenum*, but we have no compunction in synonymizing the two forms.

The specimens recorded from Bermuda by Beebe and Tee-Van as *Lophogobius pallidus* are also the same as the specimens mentioned above. They agree so well with Parr's original description that we consider *pallidus* as a synonym of *glaucofraenum*.

Parr, in his description of *pallidus*, grouped it with *L. cyprinoides* in the genus *Lophogobius*, and in our present state of knowledge of West Indian gobies, such a procedure seems to be quite proper in the present case. It must be noticed, however, that the crests are quite different in the two species,—the crest of *cyprinoides* being rather high, thin and membranous in the living fish, incapable of supporting itself when the fish is out of water, while the crest of *glaucofraenum* is low, rather wide, relatively ridge-like and by no means membranous. Whether these distinctions can be correlated with others to establish a different generic status for the two forms is a future problem.

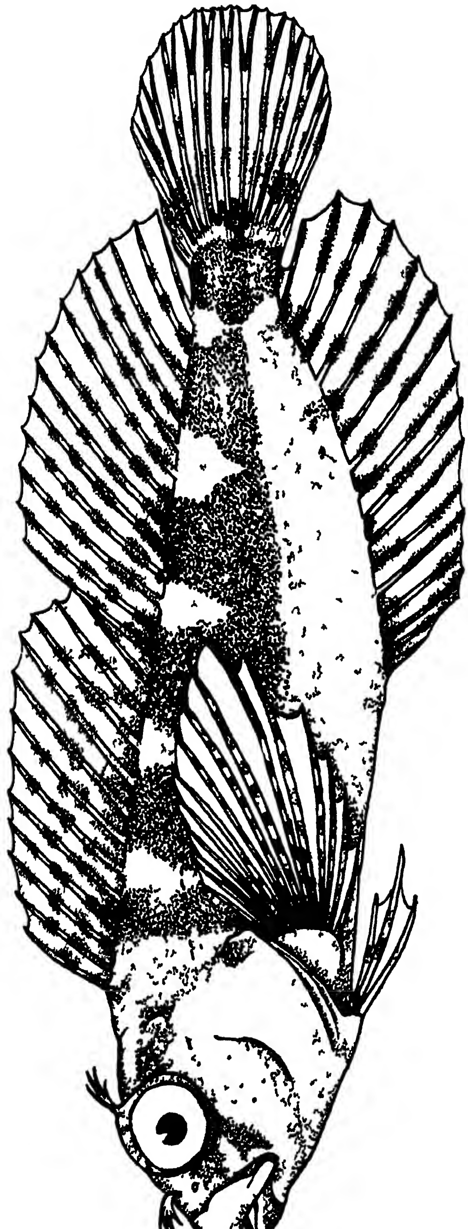


Fig 38 *Hypleurochilus bermudensis* sp nov

Family CALLIONYMIDAE

Callionymus bermudarum Barbour

Callionymus bermudarum Barbour.

Callionymus bermudarum Barbour, *Bull. Mus. Comp. Zool.*, XLVI, No. 7, 1905, *p.* 129; Bean, *Field Col. Mus.*, *Zool. Ser.*, VII, No. 2, *p.* 81.

Callionymus dubiosus Parr, *Bull. Bingham Oceano. Coll.*, III, 1930, No. 4, *p.* 130, *fig.* 36; Beebe and Tee-Van, *Zoologica*, XIII, No. 5, 1932, *p.* 120.

During the various years at Nonsuch Island a number of examples of *dubiosus*, recently described by Parr from the Bahamas, were obtained. One of these examples has been compared by Parr with the type, from which it differed very slightly.

In 1932 the junior author examined the types of *bermudarum* in the Museum of Comparative Zoology at Cambridge as well as our Bermuda material. Although our materials representing *dubiosus* have not been directly compared with the types of *bermudarum*, it is quite certain that the two forms are identical.

Parr was justified in erecting a new species for his material as the original description of *bermudarum* mentions only three dorsal spines, while Parr's material had four. In a re-examination of the type of *dubiosus* a fifth rudimentary spine was found,—this spine being well developed in the Bermuda fish. However, examination of the types of *bermudarum* show that there are 5 and possibly 6 spines. The spinous dorsal fins in this type material are in poor condition, and have evidently been damaged, making accurate counting difficult, but there are certainly more than three spines in each of the fishes examined. The discrepancy between the specimens and the description was noted before, as there is a label in the bottle containing the types, presumably written by Dr. Garman, stating "D 7 + 7, A 5."

In color, opercular spines, lateral body keels, and other characters not mentioned in the description of *bermudarum*, the two forms are alike, and *dubiosus* ought to be placed in the synonymy of *bermudarum*.

Family BLENNIDAE

Hypleurochilus Gill 1861

Hypleurochilus bermudensis sp. nov

Type: No. 33070, Museum of Comparative Zoology, Cambridge (Field No. 440), Marshall Island, Bermuda, August 8th, 1918. Standard length 40 mm.

Field Characters: Small, short-headed, rather compressed, scaleless fish with small pelvic fins of three rays each; gill-openings confined to the sides only, the membrane fully attached to the isthmus below. A short multifid tentacle above the eye and a multifid one on the anterior nostril. Color brownish to yellow-buff, heavily barred above and mottled with dark brown. Vertical and paired fins with small brown spots on the rays.

Measurements and Counts: Total length 49 mm.; standard length 40 mm.; depth 9.8 (4 in length); width of body 6.8; head 12.5 (3.2 in length); eye

3.5 (3.6 in head); interorbital space 1.5 (8.2 in head); snout 4.2 (3 in head); maxillary 4.3 (2.9 in head); snout to dorsal fin 10.8 (3.7 in length); snout to anus 24 (1.66 in length); depth of caudal peduncle 3.7 (3.4 in head); distance between openings of gill-slits ventrally 4.8 mm.; dorsal fin XII, 13; anal fin I, 15; pectoral rays 15; pelvic rays 3; pectoral length 12.3 mm.; pelvic length 8.6 mm.; scales absent.

Body compressed, especially posteriorly, deepest just behind the pectoral fins. Anterior profile with a slight downward curve immediately in front of the dorsal, then straight and slightly downward to the orbit. Profile from eye to snout straight, oblique, and at a considerable angle from the dorsal profile.

Skin naked. A four-fingered dermal tentacle over the eye slightly posterior to the eye's vertical axis, the length of the tentacle slightly more than half the height of the eye. No cirri on the nape. A multifid cirri on the anterior nostril.

Lateral line prominent, rather high up on the side, short and present on the anterior sides only, ending under the 9th dorsal spine on the right side and under the 11th dorsal spine on the left side.

Head somewhat deeper than wide; opercles smooth, the opercle ending posteriorly in a deep bay, the membrane of the opercle continued posteriorly into an obtuse flap. Gill-membranes united to each other and completely attached to the isthmus below, the gill-openings thus restricted to the sides.

Snout obtuse, its length slightly greater than the diameter of the eye.

Eye not quite round, its longest diameter oblique, medium in size (3.5 in head); its upper edge entering the dorsal profile. Interorbital space narrow (8.2 in the head).

Anterior nostril with a multifid tentacle on its posterior aspect. Posterior nostril close to the eye, without appendages. Mouth, rather small; the lips, especially the upper, rather full; maxillary extending to slightly beyond the anterior margin of the pupil.

Teeth firmly set on the jaws, their tips obtusely pointed; in a single row in each jaw, each tooth considerably curved and with a cusp on its inner basal aspect. The teeth of the upper jaw are followed posteriorly by a short space and then a single canine, in shape and size much like the remaining jaw teeth.

Dorsal fin continuous, the spines shorter than the rays, the base of the spinous portion slightly longer than that of the soft dorsal. The 1st spine is 4.2 mm. high; the fin thên slowly ascends to the 5th to the 9th spines which are all 5.8 mm. high, and then descends to the 12th which is 3.5 mm. The rays are abruptly higher, the first ray being 6.5 mm. high, the 5th to the 7th being 7.8 mm. while the 13th is 3.6 mm.

The anal fin is lower than the dorsal, the highest rays being 11th to 13th, which are 6 mm. Tips of the anal rays curved backward.

Pectoral fins extending to the vertical of the first dorsal ray, the 5th ray from the bottom longest, the lower rays much thicker and heavier than the others. Base of the pectoral nearly vertical.

Pelvic fins inserted anterior to the pectorals and immediately in back of the attachment of the gill membranes to the isthmus. Third ray considerably shorter than the anterior two, the second of which is the longer.

Color (Alcoholic specimen): General color of head brownish, that of the body yellowish-buff, becoming lighter posteriorly. Body with six large dark brown blotches on the upper two-thirds of the sides, broadest in the middle of the sides and in some cases connected with each other. Remainder of body freckled with small spots of lighter brown. Vertical and paired fins with small brown spots on the rays, forming in some cases irregular bands, most prominent on the anal, spinous dorsal and caudal fins.

Discussion: This species differs from *H. geminatus*, the only other described Atlantic species of the genus, in size of head, anal fin count, presence of canines in the upper jaw only, emarginate dorsal fin, and in color.

Family ANTENNARIIDAE

Antennarius radiosus Garman

Antennarius radiosus Garman.

Antennarius radiosus Garman, *Bull. Lab. Nat. Hist. Iowa Univ.*, 1896, *p.* 85, *pl.* 1; Bean, *Field Col. Mus., Zool. Ser.*, VII, No. 2, 1906, *p.* 89.

We have examined the specimen (U. S. Nat. Mus. No. 50,000) upon which Bean based the Bermuda record. It agrees well in general form and fairly well in color with the original description of *radiosus*, but differs in possessing a short 1st dorsal spine,—the spine itself, excluding the filaments, being of about the same length as the second dorsal spine. Unfortunately, both of these spines were broken off in our examination of the specimen.

Considering the sparseness of material and our lack of knowledge of variation within the group, it seems best to retain the identification given by Bean to this specimen, and to point out that it is by no means typical.

In the "Field Book of Shore Fishes of Bermuda" mentioned in the introduction to this paper, only the strictly shore-living species and the commoner pelagic forms such as flyingfish and dolphins are treated. The following species, already reported in the ichthyological literature of Bermuda will be included in future reports on the Deep-sea Fishes of Bermuda:

Amphioxides pelagicus Günther.
Etmopterus pusillus Lowe.
Lampanyctus crocodilus (Risso).
Coelorhynchus occa (Goode and Bean).
Regalecus glesne Ascanius.
Brama raii (Bloch).
Lirus maculatus Günther. (Reported as *Centrolophus* sp. by Goode).
Psenes pellucidus Lütken.
Eucrotus ventralis Bean.
Macrorhamphosus scolopax (Linnaeus).
Mola mola (Linnaeus).
Ranzania truncata (Retzius).

After this paper was in page proof, we received an excerpt of Dr. W. H. Longley's paper, "Preparation of a monograph on The Tortugas fishes" (Carnegie Institute Year Book, No. 31, 1931–1932, pages 299–300). It is a matter for congratulation that in the difficult field of synonomy of the West Indian fish fauna, the majority of our conclusions, arrived at independently, are identical with those of Dr. Longley.

DEEP-SEA ISOSPONDYLOUS FISHES[1]

TWO NEW GENERA AND FOUR NEW SPECIES

By William Beebe

(Figs. 39 to 42 incl.)

This is the second installment of descriptions of new forms of deep-sea fish taken on the Bermuda Oceanographic Expeditions of the Department of Tropical Research of the New York Zoological Society. They were all taken within the eight-mile circle whose center is at 32° 12′ North Latitude and 64° 36′ West Longitude, nine and one quarter miles south-southeast of Nonsuch Island, Bermuda.

The descriptions are published here in advance of the final ecological studies of the families to which these new forms belong. The monographs will appear very shortly.

Figures 39, 40, 41 and 42A are by Helen Tee-Van; figure 42B by Edward Delano.

LIST OF SPECIES

Anomalopterus megalops sp. nov.

Type: Department of Tropical Research No. 11,456; *Bermuda Oceanographic Expedition of the New York Zoological Society; Net* 280; *July* 10, 1929; 12 *miles south of Nonsuch Island, Bermuda;* 700 *fathoms; Standard length* 31 mm.

Measurements and Counts: Standard length 31 mm; depth 7.8 (in length 4); head 15.3 (in length 2); maximum thickness 6.5 (in length 4.8); eye diameter, without fold, 3.3 (in head 4.6); eye fold .48; snout 3.8 (in head 4); maxillary 8.2 (in head 1.9); interor-

[1] Contribution, New York Zoological Society, Department of Tropical Research, No. 415.

bital 2.4 (in head 6.4); branchiostegal rays 7, partially united beneath the isthmus; pectoral rays 7; pectoral length 1.9; pelvic rays 7; pelvic length 2.5; dorsal rays 21; anal rays 20.

General Description: Due to the enormous size of the head, the

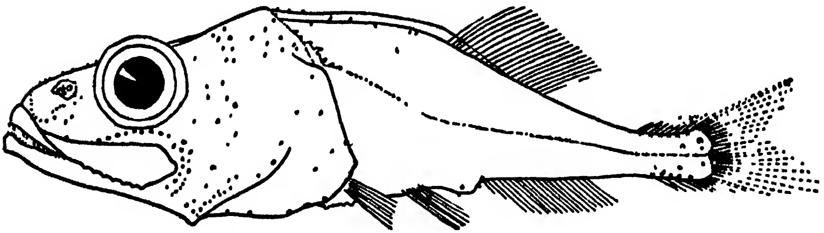


Fig. 39. *Anomalopterus megalops* sp. nov.

deepest part of the body falls far back, at about the middle of the length. From here it slopes forward gradually to a deep, blunt snout, and more rapidly posteriorly, ending in an elongated, slender peduncle.

The large eyes are high on the head, interrupting the dorsal profile, and the eye-ball is surrounded by a thick, fleshy fold, making these organs look even larger than they are. The nostrils are conspicuous, slightly nearer the anterior margin of the eye than the tip of the snout, and are above a line drawn between these two places. The narial area is very large, measuring a millimetre in diameter. The mouth is of great size, with a slight downward slope posteriorly, the maxillary ending just short of the posterior vertical of the eye.

The teeth are small, slightly curved, and present on the premaxillary, maxillary and the anterior part of the mandible. The maxillary teeth are seven in number and alternate with shallow, rounded scallops. The vomer and palatines are edentulous.

The gill openings are large; the opercula are covered with skin and the posterior margin is smooth.

The skin is scaleless and smooth except for numerous small tubercles, abundant on the head, and less so on the body, where they are scattered along the dorsal fold and the lateral line, around the anus and at the base of the caudal fin. A low dermal ridge begins at the nape and extends halfway down the back, encroaching considerably upon the anterior portion of the dorsal fin. The latter occupies about the middle third of the back. The anal originates at the

vertical from the middle of the dorsal, and extends about half its length behind the dorsal. The pectorals are inserted close to the ventral profile and are very short. The pelvics, of equal length, originate well in advance of the dorsal fin.

Discussion: My specimen, No. 11,456, must be referred to the genus *Anomalopterus* on the basis of the two dominant generic characters—the enormous size of the head and the presence of the adipose fold preceding the dorsal fin, unless a new genus be made due to the presence both of maxillary teeth and of dermal tubercles in the present specimen.

The only other species, and in fact individual of the genus, *Anomalopterus pinguis*, was described by Vaillant,[2] from off northern Africa, at a depth of 1400 metres or 765 fathoms.

Anomalopterus megalops differs from Vaillant's species in the much larger eye (4.6 in head, not 20), the presence of teeth on the maxillary, the conspicuous nostrils, increased vertical finray counts and the presence of tubercles on the skin.

Even allowance for a difference in age (*pinguis* is twice as long as *megalops*) could not account for the greatly disproportionate size of the eye, the inconspicuousness of the nostrils and the total absence of dermal tubercles.

The type is in the collection of the Department of Tropical Research of the New York Zoological Society.

Macromastax gen. nov.

Generic Characters: Elongate, moderately compressed Aleppocephalids, with naked, delicate skin, no sign of tubercles, and no nuchal dermal fold; lateral line distinct; the head large (less than 3 in length); mouth very large, with the maxillary reaching far behind the posterior margin of the orbit; the jaws nearly equal; snout short; teeth uniserial, absent from the vomer, but present on the premaxillary, maxillary, mandible and palatine; eye large; the gill membranes not joined beneath the isthmus; 9 branchiostegals; the paired fins are close to the ventral profile; the pectorals small and feeble; the pelvics well developed, just within the posterior half of the fish; the dorsal is about twice as long as the anal, originating far in advance of it, at the vertical of the pelvic base; caudal well developed, forked.

[2] 1888—Poissons, Exp. Scient. Talisman et Travailleur, pp. 160–162; Pl. XI, fig 4, 4a.

Comparison with Other Genera: This genus is immediately distinguishable from other scaleless Alepocephalids by the following characters:

From *Xenodermichthys* and *Rouleina* by the inequality of the vertical fins, the forward position of the dorsal, and the great size of the maxillary.

From *Leptoderma* by the shortness of the vertical fins, the fact that the dorsal is longer than the anal instead of vice versa, and by the great size of the maxillary.

From *Anomalopterus* and *Photostylus* (see pgs. 60 and 64) by the absence of an adipose fold in front of the dorsal fin.

In addition to its lack of scales, *Macromastax* differs most obviously from the remaining Alepocephalids which have short snouts, pelvic fins and maxillary teeth as follows:

From *Bathytroctes* (including *Talismania*) in the great length of the maxillary, in the presence of 9 instead of 7 branchiostegals, and in the absence of vomerine teeth.

From *Bajacalifornia* in the lack of a pointed, symphysial knob, and in the large size of the maxillary.

From *Narcetes* in having uniserial instead of polyserial teeth, and more than seven branchiostegals.

Macromastax gymnos sp. nov.

Type: Department of Tropical Research No. 10,829; Bermuda Oceanographic Expedition of the New York Zoological Society; Net 210; June 22, 1929; eight miles south of Nonsuch Island, Bermuda; 1000 fathoms; Standard length 35 mm.

Measurements and Counts: (These measurements were made from the fresh specimen). Total length 42.2 mm; standard length 35 mm; depth 6.5 (in length 5.4); head 12.8 (in length 2.7); eye 3.5 (in head 3.7); snout 2.1 (in head 6.1); maxillary 8.5 (in head 1.5); pectoral ca. 10; pectoral length 2.2; pelvic 7; pelvic length 6.3; dorsal 25; anal 12; 9 branchiostegals.

General Description: Body deepest immediately behind the large head; dorsal and ventral profiles almost horizontal, the slope being very slight to the short, thick peduncle. Top of head straight, dipping abruptly at front of eye to the short, blunt snout. Eye very large, almost filling the space between the top of the head and the maxillary line; pupil elliptical. Nostrils conspicuous, half-way be-

tween eye and snout. Maxillary straight, slanting obliquely downward and back, extending almost the diameter of the eye behind the posterior margin of the orbit.

There are 5 short, recurved teeth on each premaxillary ramus,

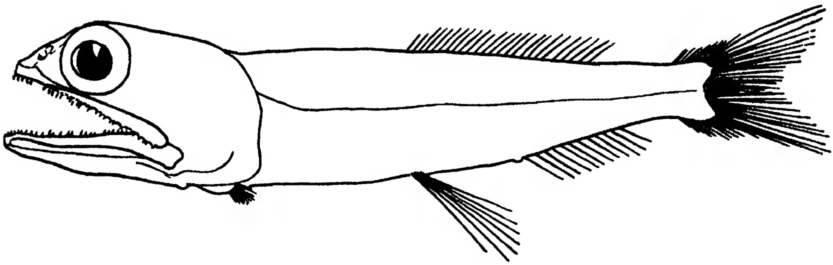


Fig 40. *Macromastax gymnos* gen et sp. nov.

and 24 along the maxillary, separated and rather irregular; on the posterior third these tend to be arranged in pairs; on the mandible are 44 teeth, equally small and curved; some of these are not in perfect alignment, but there is no evidence of biseriality; each palatine has 6 teeth, but there are none on the vomer.

Type in the collections of the Department of Tropical Research of the New York Zoological Society.

Photostylus gen. nov.

This genus differs from all the Alepocephalidae except *Anomalopterus* in having a prominent pre-dorsal fold or adipose fin along the back. It differs from that and other closely related genera (such as *Rouleina* and *Xenodermichthys*) in its steeply ascending, concave snout, small head and relatively high and well developed pectoral fins. The skin is without scales; the jaws are equal, with a prominent symphysial knob; the mouth moderately large; teeth present on the premaxillary, maxillary, mandible and palatine; 6 branchiostegals; pectorals large and placed high; pelvics small, inserted at about the middle of the body; vertical fins almost equal, far back.

Photostylus pycnopterus sp. nov.

Type: Department of Tropical Research No. 10,217; Bermuda Oceanographic Expedition of the New York Zoological Society; Net 137; May 30, 1929; 9 miles south-east of Nonsuch, Bermuda; 800 fathoms; Standard length 64 mm.

Measurements and Counts: (From fresh specimen, now shrunken slightly as to length and eye). Total length 71 mm; standard length 64 mm; depth 9.2 (in length 6.9); head 11 (in length 5.9);

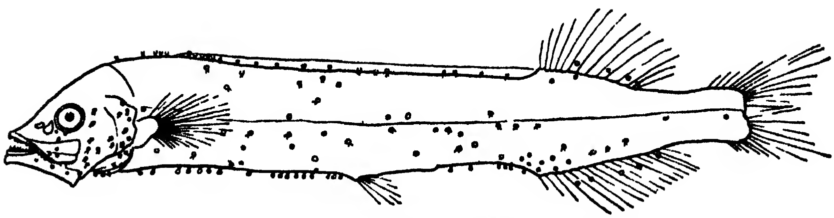


Fig 41 *Photostylus pycnopterus* gen et sp. nov.

eye 2.5 (in head 4.4); interorbital 2.5 (in head 4.4); snout 4 (in head 2.7); maxillary 5.8 (in head 1.9); branchiostegals 6; pectoral rays 18; longest pectoral ray 4.3; pelvic rays 6; pelvic length 4; dorsal 13½; anal 17½; caudal rays ca. 35; caudal tip broken.

General Description: Considerably elongate and compressed; body profiles almost horizontal, sloping very slightly backward to the tail; the nape is somewhat elevated, and the head depressed, the top of the head curving evenly down to the eye, from whence to the tip of the snout the profile is concave; the ventral profile of the mandible extends obliquely downward, with a prominent posterior angle, well below the profile of the head; the vertical fins arise from elevated, fleshy bases, considerably increasing the depth of the posterior body profile.

Head and eye both small; nostrils large, nearer eye than tip of snout; jaws equal in front, the symphysis of the mandible prolonged downward into a prominent knob; maxillary flat and greatly widened posteriorly, extending to the vertical of the posterior border of the eye.

Small teeth in uniserial rows are present on the premaxillary (27), maxillary (17), mandible (24), and palatine (2); the vomer is toothless; the teeth are close-set, but besides the symphysial gaps, there are other, occasional, narrow, asymmetrical gaps and a few replacement teeth.

The head and body are covered with an irregular scattering of photophores, elevated on stalks: these consist of a terminal, pigmented body, with a white or iridescent summit, the whole elevated on a thick. colorless stalk.

From the inter-mandibular membrane arise four pairs of singular looking organs, leaf-like but rather thick and dead white. Together with several small, adjacent patches, these seem to form an illuminating organ, comparable with nothing with which I am familiar in any other Alepocephalid.

On the nape, just back of the vertical of the fleshy base of the pectorals, there rises a thick, fleshy, median fold or adipose fin. This increases slightly in height and extends back to the dorsal, where it merges with the raised, fleshy base of that fin.

The type is in the collections of the Department of Tropical Research of the New York Zoological Society.

Macrostomias calosoma sp. nov.

Type: Department of Tropical Research No. 18,781; Bermuda Oceanographic Expeditions of the New York Zoological Society; Net 890; September 15, 1930; 12 miles south-east of Nonsuch Island, Bermuda; 600 fathoms; standard length 430 mm.

Measurements and Counts: (Made from the fresh specimen). Total length 450 mm; standard length 430 mm; depth 21 (in length 20.5); head 27 (in length 15.9); eye 6 (in head 4.5); snout 6 (in head 4.5); maxillary 28; mandible 33; interorbital 6 (in head 4.5); pectoral rays 6; pectoral length, longest ray 20, shortest rays 1.1; pelvic rays 5; pelvic length 60; dorsal rays 14; anal rays 15; snout to pectoral 30; snout to pelvic 236 (in length 1.8); scales, in a longitudinal series, 164; barbel 300 (in length 1.4, divided by head 11). Photophore counts: Hyoid 22; lateral series, P-V 79, V-A 59; ventral series, I-P 12, P-V 80, V-A 60, A-C 20.

General Description: Exceedingly long and slender, the head scarcely deeper than the body and typically Stomias-like in form.

Teeth: All slender and curved; premaxillary 6, the second a long, curved fang, first and third very small, others slightly larger; maxillary 11; mandible 10 in each half, the second long, curved, somewhat shorter than the corresponding tooth in the upper jaw, others small, sixth to tenth very small, in posterior part of jaw, in two sets of two and three; vomer 1 pair; palatines 3 pairs.

There is a round cheek light obliquely below and back of the eye. The barbel is longer and more complicated than that of *M. longibarbatus*, the other species of the genus, and takes rank with the most specialized organs of the family. It arises far forward in

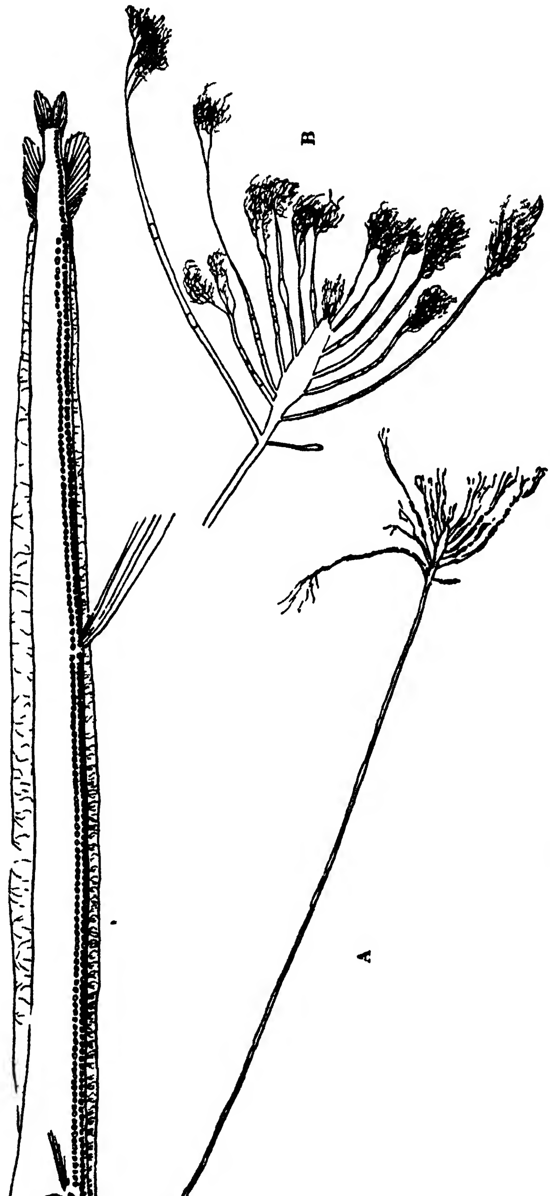


Fig. 42. *Macrostomias calosoma* sp. nov. A. Lateral view; B. End of bar bel.

the intermandibular tissue in front of the photophores, swung from a stout mass of translucent muscle. The very long stem is transparent, showing a thin, central core, and is dotted, sparsely and irregularly, with small, black chromatophores. It narrows very gradually and near the end is only about half the basal diameter. The tip consists of a long, narrow spindle of pale yellow, luminous tissue. Just above this arise two branches, the superior one short and of irregular shape, the inferior with a long stem ending in a burst of luminous yellow beads. From the origin of this pair to the tip of the bulb are about a dozen lateral branches, no two alike, some with a stem of luminous beads, others with only a terminal brush of filaments. At the extreme tip of the bulb arise several, slender, thread-like filaments. The whole forms a luminous organ of considerable power, which when glowing must look like a tassel of filmy, luminous threads.

Many clusters of small photophores are scattered on the head and around the bases of the fins, while each scale contains a light in its lower central portion. All of these, as well as the serial photophores, are directed straight downward, except the hyoid lights which point obliquely downward and back, and the subocular which is directed slightly up and back.

The pectoral fin is rather short, well formed, but of a specialized, translucent, white tissue, very evidently luminous. The rays of the pelvics are extremely long and slender, not tipped with luminous bodies as in *M. longibarbatus*. They are placed slightly behind mid-body.

Comparison: The genus *Macrostomias* is known from one other species, *M. longibarbatus* Brauer, recorded from the eastern Atlantic and Indian Oceans. *M. calosoma* differs from *M. longibarbatus* in its longer and more elaborate barbel (head contained in barbel's length 11 not 7 times); its greater depth (20.5 not 33 in length); fewer V-A photophores (59 instead of 67 to 68 in the lateral series); more numerous teeth; slightly larger eye; slightly longer snout; and in having a round, not elongate, suborbital organ.

Type in the collections of the Department of Tropical Research of the New York Zoological Society.

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LIST OF ILLUSTRATIONS

THE LITTORAL CRUSTACEAN FAUNA OF THE GALÀPAGOS ISLANDS

Figures 1 *to* 19 *inclusive*

THE LITTORAL CRUSTACEAN FAUNA OF THE GALAPAGOS ISLANDS*

By Lee Boone

Part II.—Anomura

(Figs. 1–19 incl.)

Introduction

Prior to the Harrison Williams Galapagos Expedition in 1923, and the Arcturus Oceanographic Expedition in 1925, both of which were under the directorship of Dr. William Beebe, sent out by the Department of Tropical Research of the New York Zoological Society, the known littoral Anomuran fauna of the Galapagos Archipelago consisted of four species,—two hermit crabs, the terrestial, flat-eyed *Coenobita compressus* (Guerin) and the marine *Pagurus purpuratus* (Benedict), a sand-burrower, *Hippa denticulatifrons* Miers and an elfin crab, *Petrolisthes edwardsi* (Saussure).

Three of the above-cited species were taken by William Beebe, while directing the Williams Galapagos Expedition and eleven more species were added to this faunal area, five of which are new to science.

The Arcturus Oceanographic Expedition secured fourteen species of littoral *Anomurans* in the Galapagos Islands, including representatives of all the known fauna except *Pagurus purpuratus* (Benedict) which is known only from the holotype. Of these species, one, *Coenobita compressus*, is a representative of the land fauna, but the abundance of ovigerous females taken along the intertidal zone both at Galapagos and Cocos Island by Dr. Beebe, establish evidence supporting the belief that this species visits the reefs in breeding season. Two new genera and four new species of marine hermits were taken, namely, *Nympagurus galapagensis*, *Galapagurus teevanus*, *Calcinus explorator* and *Clibanarius chetyrkini*. *Pagurus californiensis* Benedict and *P. benedicti* Bouvier, heretofore known only from the West Coast of America, were also taken in Galapagos. When it is recalled that these four new species of hermits as well as representatives of the known species were all secured at station 54, Gardner Bay, off Hood Island, in two and one half fathoms of water, from a coral rock bottom area approximately five by seven feet, the richness of the littoral crustacean fauna of the Galapagos will be better appreciated. The widely distributed "sand-bug," *Hippa denticulatifrons*, was also taken at this and other stations, by the expedition.

Of the elfin crabs, six known and one new species were secured, namely representatives of *Petrolisthes edwardsi* and *P. cinctimanus*, *P. armatus*, *P. eriomerus*, *P. galathinus* and *P. amoenus* (Guerin); *P. armatus* and *P. eriomerus* hitherto known from the Lower Californian region being here recorded for the

* Contribution, New York Zoological Society, Department of Tropical Research, No. 365.

first time from the Galapagos Islands, while *P. galathinus* and *P. amoenus*, known from the West Indies, are likewise added to the Galapagan fauna. The new species is *Pisosoma aphrodita*. The new elfin crab was also taken at station 54.

The present paper comprises the second instalment of my study of the littoral crustacean fauna of the Galapagos Islands as defined in Part One. A description and illustration of every species of Anomuran Crustacean known from the littoral zone of the Galapagos is presented, including descriptions and figures of larval forms of three species of *Porcellanids*, which latter appear to be the first American Anomuran megalops described. In only one instance has it been necessary to quote the original description, namely, Dr. Benedict's *Pagurus purpuratus*.

The line drawings were made by Mrs. Helen Ziska except figure 4, made by Mrs. E. Thane.

The photographs were made by Mr. Floyd Crosby, except that of *P. purpuratus*, received through the courtesy of the United States National Museum.

Mr. Serge Chetyrkin, preparator of the Tropical Research Station, has rendered invaluable assistance in the careful preliminary separation of the *Arcturus* collection of crustacea. I am especially indebted to him for calling my attention to one of the Anomuran megalops, which he found while searching the plankton.

The authorities in charge of the American Museum of Natural History, have kindly granted me the full privileges of study in the Department of Lower Invertebrates.

As in the preparation of part one of this report I am deeply indebted to Dr. William Beebe, Director of the Tropical Research Station, for his unfailing generosity in granting me every facility and encouragement in this work.

List of Species Described in this Paper

Order DECAPODA

Tribe ANOMURA

Family PAGURIDAE

Genus *Pagurus*

Genus **Galapagurus**, gen. nov.

List of Species—*Continued.*

Order: Decapoda

Tribe: Anomura

Family Paguridae

Family: Paguridae

Key to the Galapagos genera of the Family Paguridae

A. Chelipeds rarely subequal, the left usually the larger; fingers moving in a vertical plane, corneous at tips, spoon-excavate. Carapace not rostrate. *Pagurus*

B. Chelipeds strikingly unequal, the great cheliped has the carpus and propodus, which latter is conspicuously larger than the entire carapace, bent inward from the carpal base at approximately an obtuse angle to the proximal portion of the leg; the propodus (of the only species so far known) is five-sevenths as high as long, with the outer face decidedly convex and the inner

face with a bowl-like concavity which is deepest proximally. Carapace with a prominent rostral and part of well developed median lateral projections. *Galapagurus*

C. Chelipeds strikingly unequal, propodus of the great cheliped sharply deflected near the base, the outer surface flat, with the contour of its outer lateral margin convex, tapering, and that of its inner lateral margin but little curved, each margin armed with spine-like teeth. Propodus and carpus of the small cheliped similarly sharply deflected about midway the carpus and lying closely appressed to the side of great cheliped. Carapace with frontal margin slightly sinuate, rostrum vague *Nympagurus*

D. Chelipeds unequal, the left the larger. Fingers moving in a vertical plane, calcareous at tips, spoon-excavate. Carapace with a small point as rostrum. *Calcinus*

Genus *Pagurus*

Key to the Galapagos species of the Genus *Pagurus*

I. External maxillipeds widely separated at base. Right cheliped larger than the left. Fourth pair of legs subchelate.

A. Propodus of great cheliped with a long oval contour; the maximum width being equal to half the length of the propodus; the dorsal surface is but little convex and is armed with long, spike-like teeth which are arranged in five approximately longitudinal rows, two of which are marginal, two just inside the margin, and one median; there are also a few irregularly placed spines but no granules between the rows; propodus setiferous. Carapace with the frontal margin blunt, slightly sinuate *benedicti*

B. Propodus of large cheliped with a symmetrical outline and fringed from the tips of the fingers to the wrist with blunt spines. Those on the outer margin originate on the lower surface and project on the upper surface. A strong ridge extends from the tip of the dactyl backward to the wrist. Entire upper surface of hand paved with large, flattened compound granules which appear to be hemispherical and a little elevated above the true surface, often showing irregularly shaped fissures between them. The tubercles on the inner margin of the propodus are not so thickly set as on the outer margin. The median projection of the front is rendered sharp by a rostral point which originates on the upper surface and extends beyond the margin. The triangular lateral projections are not armed with a spine (after Benedict) .. *purpuratus*

C. Propodus of great cheliped suborbiculate, smooth; about five times as wide as that of the small cheliped; which is exceedingly feeble. Dactyli of the first and second ambulatories shorter than the propodi of the same. Rostral point acute, lateral projections angulate but less prominent. *californiensis*

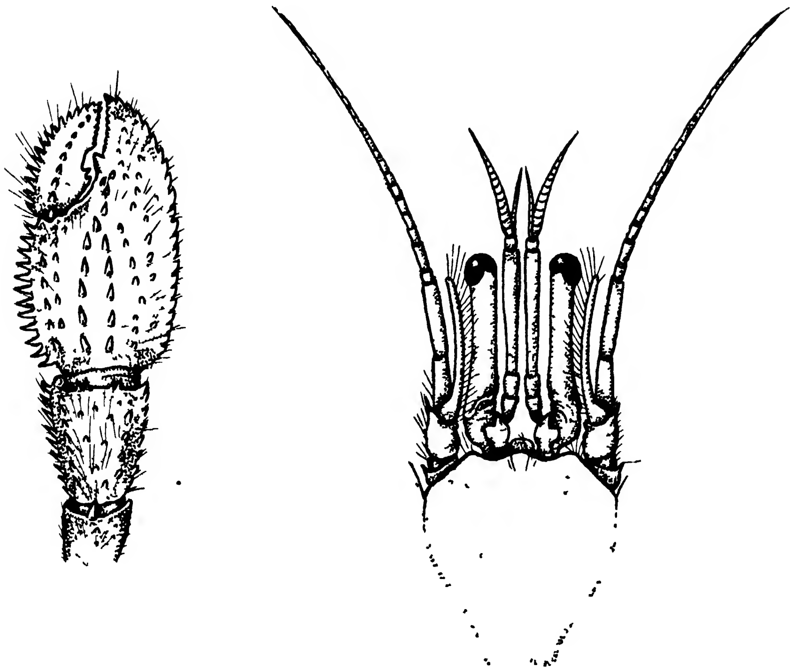

Fig. 1. *Pagurus benedicti* (Bouvier): outer side of cheliped; dorsal view of carapace. Both enlarged.

Pagurus benedicti (Bouvier).

Eupagurus minutus Benedict, 1892, Proc. U. S. Nat. Mus., XV, p. 14.

Eupagurus benedicti Bouvier, 1898, Bull. Mus. Nat. Hist. Nat., Paris, IV, p. 381. (Notes that *E. minutus* Hess, a different species has priority to the name.)—Rathbun, 1910, Proc. U. S. Nat. Mus. XXXVIII, p. 557, pl. XLVIII, fig. 1.—Boone, Bull. Amer. Mus. Nat. Hist., 63, p. 143, fig. 1, 1931. (In press.)

Name.—Named in honor of Dr. James E. Benedict, who first described the species.

Diagnostic Characters.—Carpus and propodus of great cheliped armed with five longitudinal rows of sharp spines, also a few scattered spines, these rows being continuous on the fingers.

Type.—Dr. Benedict's type, a very young adult, was collected in the Gulf of California and is deposited in the United States National Museum.

Galapagos Distribution.—Arcturus station 54, Gardner Bay, Hood Island, Galapagos Islands, 2½ fms.

General Distribution.—Gulf of California southward to Peru, also Galapagos Islands.

Material examined.—One male, two ovigerous females and one very young specimen, from Arcturus station 54, hidden in coral rock crevices, from 2½ fms.

Technical Description.—Approximate body length from tip of rostrum to tip of telson uncoiled 11 mm.; carapace 4.5 mm. long, 3 mm. wide at anterior margin, great cheliped 9.5 mm. long.

Carapace with anterior margin blunt, slightly sinuate. Anterior region of carapace with soft semicalcareous plate which has the lateral margins decidedly convex anteriorly, but narrowing and converging posteriorly; the posterior region of the carapace is membraneous and forms two large convex lobes.

The ocular peduncles are not quite as long as the width of the anterior margin of the carapace and are cylindrical; the cornea are subspherical, terminal, not at all dilated, composed of rather large hexagonal facets. The ocular scale is small, separated by a distance equal to its basal width from the other scale, with the lateral margins convex, the inner distal area produced to a triangulate apex and the outer distal area excavate and not produced.

The internal antennae have the peduncular joints slender, cylindrical, the distal one being gradually dilated distally and extending slightly beyond the cornea; the flagellum is typically small, biramose, extending almost to the distal margin of the carpus of the cheliped.

The external antennae have the basal joint about two-thirds as wide as the eyestalk and produced to a rather broad triangular tooth on its outer distal border; the inner distal margin is truncated and supports the long slender sickle-shape acicule which has the apex outward-directed, finely serrate, and reaching to the base of the cornea; the inner lateral margin and distal end are fringed with long stiff setae; the second and third joints are stocky, the fourth is long, slender, cylindrical, reaching to the base of the cornea, the flagellum is composed of about 45 annulations and is slightly longer than the first ambulatory leg.

The external maxillipeds are well separated.

The chelipeds are unequal, the right is much the larger. It has the proximal joints small, the ischium is produced to a long acuminate point which reaches almost half the length of the merus; the merus is of moderate length, trigonal, narrow basally and widening distally; the carpus is almost as long as the merus, narrow basally widening distally, its distal width being four-fifths of its length; the upper carpal surface is broad but little convex and armed with several longitudinal rows of sharp spinelike teeth, which are continuous with similar rows of spines on the propodus. The propodus is about twice as long as the carpus, the palm and fingers each being about as long as the carpus; the contour of the propodus is a long oval, the maximum width being equal to almost half the length of the propodus; the dorsal surface of the propodus is but little convex and is armed with long, spike-like teeth which are arranged in five approximately longitudinal rows, two of which are marginal, two, submarginal and one median, there are also a few irregularly scattered spines present between these rows. The propodal finger is slightly wider basally than the fixed finger

but they are otherwise similar, slightly gaping, with the cutting edges each furnished with a few large teeth, the distal parts curved and meeting. The rows of spines on the palm are continuous on the fingers, the hinged having a marginal, and a submarginal row, while the propodal finger has a marginal and two inner rows of spines; both the carpus and propodus are furnished with numerous long setae, those near the margins being heavier.

The first and second pairs of ambulatory legs are subequal and those of the right and left sides are equal to each other. Each has the ischium compressed, three-fourths as long as the merus; the merus is long, convex on its upper surfaces; the carpus is similar but only two-thirds as long as the merus; the propodus is compressed cylindrical, tapering distally; about twice as long as the carpus; the dactyl is very slender, decidedly compressed, a trifle longer than the propodus, curved and tapering distally to a sharp horn-colored tip; the ventral margin is armed with a series of seven acicular but smaller horn-colored spines and the anterior lateral face is armed with a similar row of spines. Both the dorsal and ventral margins of the merus, carpus, propodus and especially the dactyl are fringed with conspicuous long setae.

The fourth pair of legs are subchelate, the propodus being squarish with the distal margin slightly rounded, the distal third of the dorsal surface covered with squamae, the dactyl arises from the anterior laterodistal angle and is slightly longer but less than half the width of the propodus; the dactyl terminates distally in a distinct curved spine and is armed along its convex lateral border with a large brush of setae.

The fifth legs are typically small, bent and chelate; the male paired genital apertures are subcircular orifices on the coxal joints.

The abdomen is small, asymmetrical, coiled, membraneous, with four biramose appendages on one side only (one each on the second, third, fourth and fifth segments); the last segment is squarish, calcareous; the telson is transversely segmented, the proximal portion being but little more than half the length of the distal portion and having its distal margin produced to a rounded median process on either side of which the margin is recurvate; the distal portion of the telson is cut midway its lateral margins by an incision on each side; there is a similar median incision on the distal border which latter is asymmetrically produced each lobe being armed with distinct spines along the margin. The rhipidura offer no specific features.

Pagurus purpuratus (Benedict).

Eupagurus purpuratus Benedict, Proc. U. S. Nat. Museum, vol. XV, p. 15, 1892.

Diagnostic Characters.—Propodus of large cheliped with a symmetrical outline and fringed from the tips of the fingers to the wrist with blunt spines. Those on the outer margin originate on the lower surface and project on the upper surface. A strong ridge extends from the base of the propodus to the tip of the dactyl. Entire upper surface of propodus paved by large, flattened, compound, hemispherical granules separated by pits. A sharp rostral point arises on the upper surface and extends beyond the margin.

Fig 2 *Pagurus purpuratus* (Benedict) A, dorsal view of type, B, profile of same C, side view of chelipeds All enlarged Photograph by U S National Museum

Type.—This species was described from a single specimen from the Galapagos Islands and is deposited in the United States National Museum.

Galapagos Distribution.—Galapagos Islands (type-locality).

General Distribution.—Galapagos Islands.

The following is the original description of the species:

Technical Description.—"The median projection of the front is rendered sharp by a rostral point which originates on the upper surface and extends beyond the margin. The triangular lateral projections are not armed with a spine. The eye stalks are stout and long. The eye scales are acute, concave, and have a prominent, slender, subterminal spine. The lateral projection of the second article of the antennal peduncle is long and is conspicuously armed

with spines on its inner margin. The peduncle is but little if any longer than the eye. The acicle is setose and much shorter than the eye. The peduncle of the antennula is much longer than the eye.

The carpus of the large hand widens out evenly from the merus, making the outline straight; outer margin unmarked by special line of granules or spines; inner margin defined by a row of five or six spines which are very sharp and point forward; upper surface coarsely granulated. The hand has a symmetrical outline and is fringed from the tips of the fingers to the wrist with blunt spines. Those on the outer margin originate on the lower surface and project above the upper surface. A strong ridge beginning at the tip of the dactyl runs backward and is continued on the manus and ends at the wrist. The whole upper surface of the hand is paved with large flattened compound granules. These granules seem to be hemispherical and a little elevated above the true surface, often showing irregular shaped fissures between them. The tubercles or spines on the inner margin of the hand are not so thickly set as on the other.

The carpus of the small cheliped has a single crest armed with three or four strong spines. The hand has a curved oblique face and also a horizontal face equally prominent. The hand is also paved with compound granules. The lower margin of the oblique face is sparsely set with tubercles.

The ambulatory legs are slender. The dactyls are curved and spinose. The propodus and dactyl of the second pair on the left side are very thickly fringed with hair above and below. These articles are also seen to be wider and much more prominently grooved than the similar members of the other legs. As I have never seen this character before, I conclude that it may be accidental.

Color in alcohol, dark purple.

Described from a single specimen from the Galapagos Islands.

Pagurus californiensis (Benedict).

> *Eupagurus californiensis* Benedict, Proc. U. S. Nat. Mus., vol. 15, p. 21, 1892. Faxon, Mem. Mus. Comp. Zool. vol. 18, p. 55, pl. 77, fig. 2 2f, 1895. Schmitt, Univ. Calif. Pub. Zool. vol. 23, p. 13, fig. 93, a, b, 1921.

Names.—This species derives its name from the type-locality.

Diagnostic Characters.—Hand of great cheliped suborbiculate, smooth; about five times as wide as that of the small cheliped. Dactyli of first and second ambulatories shorter than the propodi. Rostral point acute, lateral projections angulate but less prominent.

Type.—Dr. Benedict's type material came from Catalina Harbor, California; 30 to 60 fathoms, and is deposited in the United States National Museum.

Galapagos Distribution.—*Arcturus* station 54, Gardner Bay, off Hood Island.

General Distribution.—California; off Cocos Island, and the Galapagos Islands.

Material Examined.—Two small specimens were taken at Station 54, Gardner Bay, off Hood Island, by William Beebe, while diving in 15 feet of

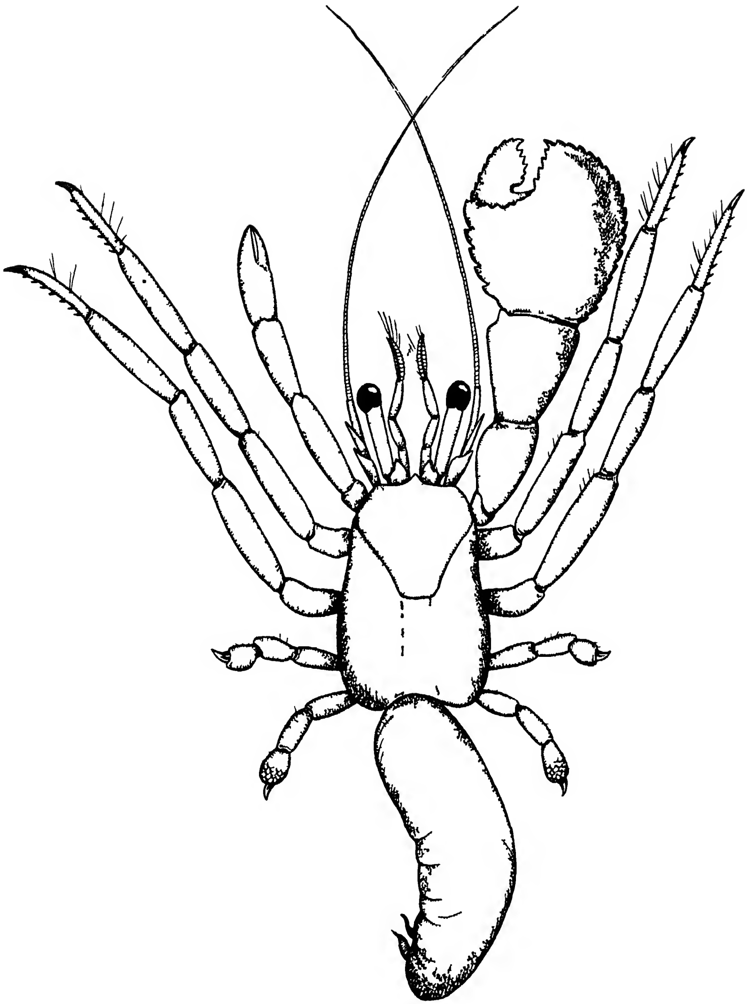

Fig 3 *Pagurus californiensis* (Benedict) Enlarged

water, and are deposited in the collections of the New York Zoological Society.

Technical Description—Carapace with the median projection shallow, triangulate, distinctly in advance of lateral projections Anterior region of carapace covered with globose-pyriform calcareous plate; lateral walls, posterior region membraneous swollen. Abdomen (broken) apparently offers no specific features.

Ocular peduncle stout, cylindrical, only two-thirds as long as the width of the anterior margin; cornea spherical, conspicuously dilated; composed of numerous distinct hexagonal facets; ocular scales well separated, produced to an acuminate triangulate point, outer lateral marginal diagonal.

Inner antennae with peduncular joints slender, cylindrical, extending beyond the eyestalk by the length of the distal two-thirds of the last joint and the biramose flagellum which reaches to midway the carpus of the great cheliped.

The external antennae have the basal joint produced to a triangulate point on its external distal angle; the acicule is slender, tapering, out-curved and reaches to about midway the cornea; the second and third joints are stocky; the fourth joint is very slender, cylindrical, quite as long as the first three joints taken together; the flagellum consists of about sixty-eight annulations and reaches a little beyond the tip of the great cheliped.

The external maxillipeds are well separated.

The chelipeds are conspicuously unequal. The right cheliped has its propodus about a third wider than the width of the carapace at the anterior margin, while the left cheliped is so small that the width of its propodus is less than a fifth of that of the right cheliped; the left cheliped scarcely reaches to the base of the propodal finger of the right cheliped and is readily confused in size with the propodus of the adjacent ambulatory leg. The great cheliped has the proximal joints substantially developed; the ventral margin of the ischium is produced distally into an acuminate projection; the merus is short widening distally but much smaller than the carpus; the carpus broadly triangular and moderately convex on its dorsal surface, its distal width being equal to its length; its lateral margins are accentuated by a series of low denticles; its dorsal surface is microscopically punctate. The propodus is 4 mm. long, and 3.5 mm. greatest width; the finger is 1.5 mm. long; the contour of the propodus is suborbicular with the convex lateral margins a convex, crenulated carina and the dorsal surface convex, smooth, glabrous; propodal finger a little wider basally than the hinged finger, both with the cutting edges dentate, the tips curved, acuminate; a row of submarginal low squamae, each of which give rise to a tuft of small setae, parallels the cutting edge of each finger.

The small cheliped scarcely reaches to the base of the propodal finger of the large cheliped and is decidedly compressed laterally; the merus, carpus and propodus are approximately subequal in length, the carpus being as long as that of the large cheliped; the small propodus is scarcely one-third as wide as long; the fingers which are subequal are slightly more than one-half of the entire propodal length; they fit closely have the cutting edge finely crenulate and excavate within; the distal half of the fingers are furnished with a series of tufts of fine setae.

The first and second pairs of ambulatory legs are subequal and those of the opposite sides are also equal; they exceed the length of the great cheliped a trifle. Each has the ischium elongate, the merus a third longer than the ischium; the carpus slightly more than half as long as the merus; the propodus equal in length to the merus, and the dactyl scarcely three-fourths as long as the propodus; the entire leg is slender and laterally compressed, the dactyl is slightly curved,

tapering tipped with a horny spine and armed along its inferior lateral margin with six forward-directed spines.

The fourth pair of legs are subchelate, the propodus is broadly convex and crenulate on its posterolateral margin; the dactyl is basally half as wide as the propodus and is tipped distally with a curved spine; the dactyl is twice as long as it is wide.

Galapagurus, gen. nov.

The great cheliped has the carpus and propodus, which latter is conspicuously larger than the entire carapace, bent inward from the carpal base at approximately an obtuse angle to the proximal portion of the leg; the propodus is five-sevenths as high as long, with the outer face decidedly convex and the inner face with a bowl-like concavity which is deepest proximally.

Fourth pair of legs subchelate.

Carapace with a prominent median rostral point and two well developed lateral points.

Telson terminating in two unequal triangulate lobes.

Genotype.—Galapagurus teevanus, sp. nov. from Arcturus station 54, Gardner Bay, off Hood Island, depth 2½ fathoms; William Beebe, collector; deposited in collections of the New York Zoological Society.

Galapagurus teevanus, sp. nov.

Name.—I take pleasure in naming this remarkable species for Mr. John Tee-Van, assistant to the Director of the Tropical Research Station.

Diagnostic Characters.—Chelipeds strikingly unequal, the great cheliped has the carpus and propodus, which latter is conspicuously larger than the entire carapace, bent inward from the carpal base at approximately an obtuse angle to the proximal portion of the leg; the propodus is 7 mm. long, 5 mm. high, with the outer face decidedly convex and the inner face with a bowl-like concavity which is deepest proximally. External maxillipeds widely separated. Telson terminating in two unequal triangulate lobes. Rounded fleshy projection of abdomen extending over the male genitalia.

Type.—The holotype was taken at *Arcturus* station 54, Gardner Bay, off Hood Island, by William Beebe, while diving in 15 feet of water.

Galapagos Distribution.—Known only from the type-locality, Hood Island, Galapagos Islands.

Technical Description.—Carapace with the anterior margin produced to a prominent, acute, triangulate point; the lateral points also triangulate but less advanced than the median projection. Anterior region of the carapace covered with a calcareous plate which is only three-fourths as long as wide and has the lateral margins rounded and decidedly convergent, the posterior margin being scarcely half as wide as the anterior margin. The dorsal surface of this plate is glabrous, marked by two curved "cervical" grooves. The posterior region is membraneous, decidedly globose, deeply excavate in the median posterior region on either side of which it is produced into a large convex lobe, which is fringed with setae on its posterior margin.

The ocular peduncles are only a little more than half as long as the width

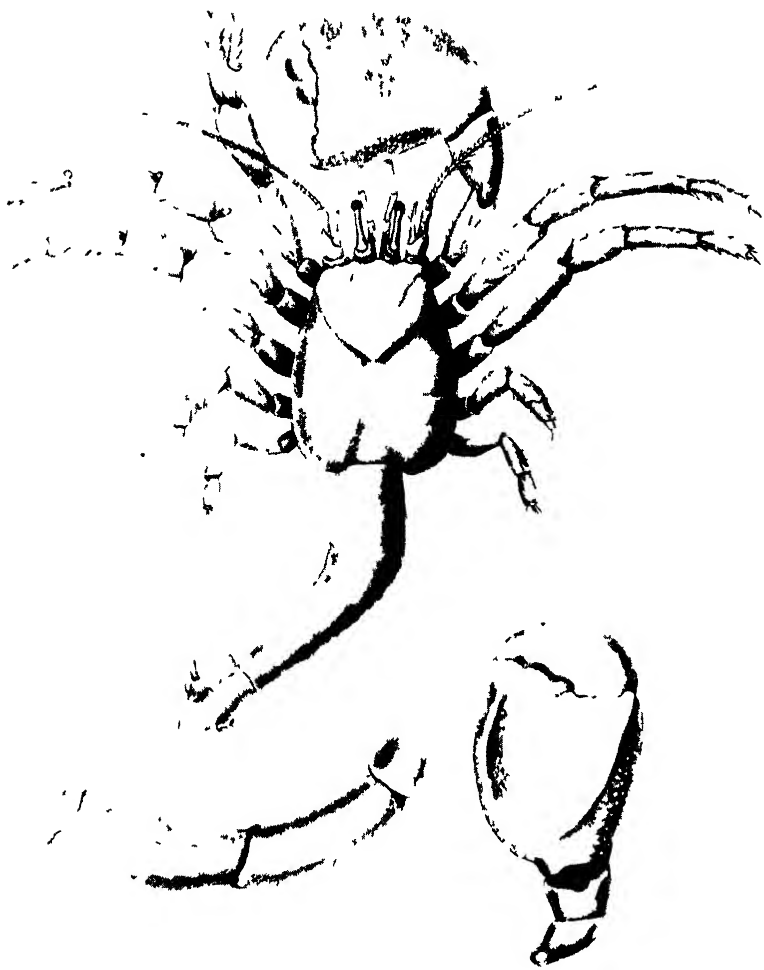

Fig 4 *Galapagurus teevanus*, new species, type $\times 5$, A, dorsal view lower left figure, type of fifth leg greatly enlarged, lower right figure, inner side of great cheliped much enlarged

of the anterior margin of the carapace; they are cylindrical, slightly dilated basally and fringed along the dorsal and inner surfaces with long, fine setae set in small tufts. The cornea are large, ovoid, composed of numerous distinct hexagonal facets; the ocular scales are well separated, produced to an acuminate, triangulate point, convex on the dorsal surface.

The inner antennae are cylindrical, long, exceeding the length of the eyestalk by the length of almost the entire distal joint which is three-fourths as long as the eyestalk; the flagellum is biramose, the inferior branch being quite small and slender, the superior branch is about as long as the last peduncular joint and consists of a stout proximal portion, composed of about twenty-two tapering rings and a slender distal whip composed of six longer articulations; there is a long close brush of setae on the ventral side of the conical proximal portion of the superior flagellum.

The external antennae have the basal article broad, produced to a large, blunt, triangulate tooth on its external distal angle and to a minute process on its inner distal angle, the acicule slightly exceeds the eyestalk in length and is decidedly tapering and outward pointing; it is armed with numerous very long, radiating setae along the lateral and distal margins; the next joint is as long as the outer side of the preceding one and two-thirds as wide, with its lateral margins convex, and tapering slightly distally, the next article is about one and one-half times as long as the preceding one and is decidedly compressed cylindrical; the flagellum is composed of one longish basal and about ninety shorter annulations, each of which is furnished distally with several slender, long, radiating setae; the flagellum is a little longer than the first pair of ambulatory legs.

The external maxillipeds are widely separated; the space between them being greater than the width of one maxilliped.

The exognaths of both pairs of maxillipeds are flagellate.

The chelipeds are conspicuously unequal; the right being many times greater than the left one. The great cheliped is decidedly curved and enlarged distally; it is 13 mm. long, the propodus being 7 mm. long and 5 mm. wide, decidedly thin and curved, the inner face being a bowl-like concavity and the outer face correspondingly convex; the propodus is larger both ways than the carapace of the animal. The coxal joint of the great cheliped is trihedral; the basis is small, the ischium is short and produced to an acuminate process on the ventral inner distal angle; the merus is trihedral, the ventral face being broad, convex, with a crescentic excavation distally; the lateral faces converge dorsally to a rounded narrow dorsal face; the inner lateral face is produced distally into a rounded flat process which projects over the carpus; the corresponding distal part of the inner lateral face is similarly rounded but less produced; the carpus is but little longer than the merus and of somewhat similar shape but is thicker; the dorsal surface is raised to a prominent median longitudinal carina on either side of which it slopes abruptly to a lateral carina; the outer lateral face below this carina is produced on the distal two-thirds forming a convex, inferior border; the carpus and propodus, which latter is conspicuously larger than the entire carapace, are bent inward from the carpal base at approximately an obtuse angle to the proximal portion of the leg. The propodus is 7 mm. long, 5 mm. maximum width, with the outer face decidedly convex and the inner face with a bowl-like concavity which is deepest proximally; the inferior lateral margin of the propodus is quite convex, subcarinate; the superior lateral margin is a rather straight line which slants diagonally upward

from the propodal base to the distal angle; the distal border of the propodal finger is diagonally truncated, the lower half is produced but very little in advance of the upper half, but is gently curved inward; there is one prominent sub-basal triangulate tooth on the cutting edge, followed distally by about half a dozen crenulate denticles; there is a shallow diagonal depression on the propodus near the propodal finger. The hinged finger is quite large, its base being half as wide as the distal margin of the propodus and having its outer lateral margin decidedly convex and its inner margin, or cutting edge slightly excavate with one medium-sized triangulate tooth more distal in position than the large triangulate tooth; the tip is an acuminate horny spine. There are quite a few, low, nearly flat, round tubercles on the outer face of the propodus, which is also sparsely setigerous.

The left cheliped is exceedingly small, being of no greater diameter and shorter by half the length of the dactyl, than the first ambulatory leg. The first and second joints of the left cheliped are small; the ischium is short and produced to an acuminate point on the ventral distal margin; the merus is long, slender, compressed cylindrical; the carpus is similar and subequal to the merus; the propodus is as long as the carpus and of no greater diameter; the propodal finger comprises one half of the entire length of the propodus; the fingers are very similar, the propodal being slightly the thicker, the hinged finger being a little more curved; both are acuminate and have the cutting edges fitted closely upon each other. The upper surface of the carpus and the entire propodus are covered with rows of sparsely set, long radiating hairs.

The first and second pairs of ambulatory legs are subequal and those of the right and left sides are equal to each other; they are not quite as long as the great cheliped. Each ambulatory leg has the coxopodite well developed; the basis short, the ischium elongated; the merus about twice as long as the ischium; the carpus two-thirds as long as the merus and produced to a blunt point at the distal dorsal apex; the propodus is about a third longer than the carpus but is distinctly more compressed laterally and is produced on its distal lateral margins into a laminar rounded process which projects over the base of the propodus; the dactyl is very slender and about one-fifth longer than the propodus, slightly curved and armed distally with a horn-colored spine; there are also a series of nine sharp horn-colored spines along the inferior margin of the dactyl; a series of nine similar but shorter spines form a longitudinal subdorsal line on the inner side of the dactyl. The entire leg is slender, compressed laterally, and fringed with long setae on the dorsal edge.

The fourth legs are small and curved; the ischium is elongate, flattened and produced to an acute point on its distal angle; the merus is similar to but a third longer than the ischium, and has its outer distal margin rounded and furnished with a fan-like cluster of setae which are as long as the merus; the carpus is bent almost at a right angle to the merus and is quite narrow basally, widening distally and with the outer distal angle produced; the outer edge is furnished with a long brush of setae; the propodus is about as long as the carpus but is approximately of equal width throughout its length; the rasp consists of five or six denticles on the inner distal border; the dactyl arises from the

distal border of the propodus and is triangulate with the tip curved and acuminate and with the inner lateral margin set with several small denticle-like spines, also several long setae.

The fifth pair of legs are characteristically small and reflexed. There is a long, narrow, calcareous bar between the coxal joints. In the male the coxal joints bear the paired small genital apertures near the base of the ventral face; each of these openings is guarded by a fan-like tuft of setae. The coxal joint is dilated, cylindrical; the basis is minute; the ischium is somewhat longer; the merus is twice as long as the ischium; the carpus is two-thirds as long as the ischium but slenderer; the propodus is a little longer and more robust than the propodus; the distal end is slightly dilated and the outer distal half of the outer side is covered with squamae; there is a terminal-lateral brush of long spiny setae; the longest of these setae are longer than the propodus; the dactyl is short, curved, acute.

The abdomen is small, coiled, asymmetrical, devoid of segmentation, except distally. On the anterior ventral surface there is a rounded, median fold of tissue which projects over the proximal parts of the fifth pair of legs, forming a pad-like cover over the genitalia. The last abdominal segment is rectangular, wider than long and very convex dorsally; the telson has the proximal segment calcareous, and shaped similar to but slightly shorter than the preceding segment; the distal portion of the segment is twice as long as the proximal portion and is membraneous, or very weakly calcareous; the proximal three-fourths of the distal segment of the telson is convex with its lateral margins rounded; the distal fourth of this segment is separated from the preceding part by a pair of deep lateral incisions; there is also a deep median incision on the distal margin. These three incisions are so acute, that the distal part of the posterior telsonic segment is cut into two unequal triangulate lobes which have their margins finely crenulate. The rhipidura are strikingly unequal; the peduncle is large and convex on its upper face; the anterior branch is large, clavate, with a broad rasp; the small branch is similar but weaker.

The abdominal appendages in the male offer no specific character.

The female of this species is unknown.

Nympagurus, gen. nov.

Chelipeds strikingly unequal; the propodus of the greater cheliped sharply deflected near the base, the outer surface flat, with the contour of its outer lateral margin convex, tapering, and that of its inner lateral margin usually armed with spine-like teeth. Propodus and carpus of the small cheliped similarly sharply deflected about midway the length of the carpus, and lying closely appressed to the inner margin of the great cheliped, the two together forming the operculum.

Carapace with the frontal margin slightly sinuate, rostrum vague. External maxillipeds widely separate.

Genotype.—Nympagurus galapagensis, new species, taken at Arcturus Station 54, Gardner Bay, off Hood Island, Galapagos, depth 2½ fathoms, by William Beebe.

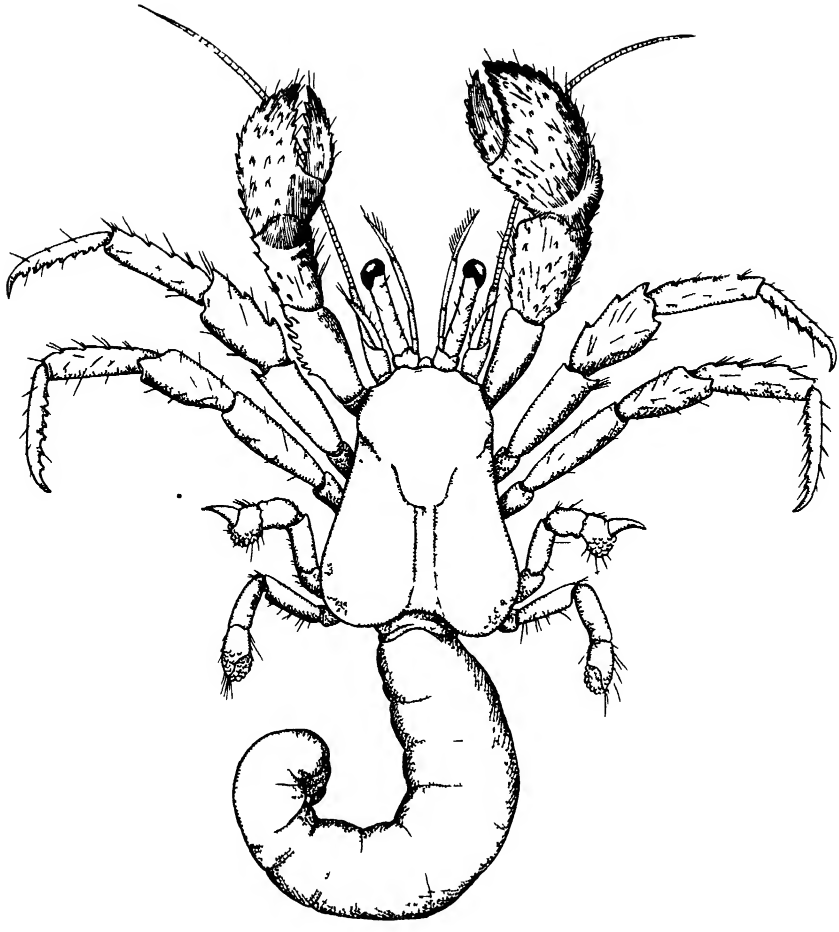

Fig 5 *Nympagurus galapagensis*, new species, type ×5

Nympagurus galapagensis, sp. nov.

Name.—This species takes its name from the type locality.

Diagnostic Characters.—Propodi of chelipeds unequal, the greater propodus sharply deflected near the base, the outer surface flat with the contour of its outer lateral margin convex and tapering, and its inner lateral margin but little curved; each margin armed with a row of regularly set, long, sharp, upward-directed, spine-like teeth. Additional spine-like denticles on the outer surface. Smaller cheliped similarly deflected midway the carpus; this bent portion lying beside that of the large propodus and forming the operculum.

Type.—The holotype, an ovigerous female, was taken at *Arcturus* Station

54, Gardner Bay, off Hood Island, by William Beebe, while diving in 15 feet of water. It is deposited in the collections of the New York Zoological Society.

Galapagos Distribution.—*Arcturus* station 54, Gardner Bay, off Hood Island.

General Distribution.—Known only from the type-locality.

Technical Description.—Approximate body length, tip of rostrum to tip of telson uncoiled 27.5 mm.; carapace 8.5 mm. long; 4 mm. wide at anterior border; great cheliped 6 mm. long.

Carapace with the frontal margin slightly sinuate, rostral point vague, only suggested by the shallowly protruberant median area. Anterior region of the carapace with a shield-shape calcareous dorsal plate whose posterolateral margins decidedly converge. Lateral walls and posterior region subglobose, soft, membraneous.

Ocular peduncles quite as long as the width of the anterior border of the carapace, cornea terminal, shining black, slightly dilated, subspherical, composed of exceedingly small, hexagonal facets; the ocular scale is small, wider than long, its lateral margins convex but unlike each other; the inner margin being longer and terminating distally in an acuminate point; the outer lateral margin of this point is abrupt and longer than the inner one. The scales are separated from each other by a space about two-thirds as wide as the scale.

The external antennae have the peduncular article fitted into the antero-lateral angle of the carapace basally and with their outer distal angle produced into a slender, acuminate tooth which is almost as long as the wider proximal part of the joint; the acicule arises from the inner distal region of the first joint and is slender, trigonal, tapering decidedly curved, the inner lateral margin being convex, the outer concave, the apex forward and outward directed. There are a series of long, stiff setae spaced on the inner lateral margins of the acicule, similar to those on the dorsal surface of the eyestalks. The second and third peduncular joints are short; the fourth joint is very slender and about as long as the first three joints taken together. It supports the flagellum which is composed of many fine short annulations and extends almost to the tip of the first ambulatory leg. There are a few, fine, short setae on the distal margins of the annulations.

The peduncles of the inner antennulae are slender, cylindrical and extend about as far forward as the eyes; the flagellum is biarticulate, both branches being short, subequal in length, the ventrally placed one is slender, the dorsal branch stout and furnished with a heavy brush of setae on its lower side.

The external maxillipeds are well-separated and are furnished with several tufts of unusually long bristly brushes of setae.

The chelipeds are unequal in the female, the right, being distinctly the larger. It has the coxal joint well-developed, four-sided; the basis very small, fused with the ischium, which is short and produced on its anterior ventral side into a long, pointed, tooth-like process which dove-tails with a process on the ventral margin of the merus; the merus is rather short, compressed on its upper and lateral sides and with the distal half of the ventral face excavate and defined by a sharp margin which bears several spine-like teeth. The carpus is about as

long as the merus and is much enlarged distally and truncated, its upper or dorsal surface being flattish and armed with numerous long, sharp, upward and forward directed spines which form broken rows and are surrounded by a rather dense coating of long setae. The outer lateral face of the carpus is flat, armed with a few denticles and is produced on its distal ventral region to a rounded lobe; the inner lateral face of the carpus is flat and oblique; the propodus is sharply bent near the base, there being a small proximal region which is on the same plane as the carpus while the remaining surface is abruptly bent downwards, almost at right-angles forming the external face of the operculum when the crab is withdrawn into the mollusk shell. This external (upper) surface of the propodus is flat with the contour of its outer lateral margin convex and tapering distally and the inner lateral margin but little curved; each margin is armed with a row of regularly set long sharp upward directed spine-like teeth; on the inner half there is a broken submarginal row of lower denticles approximately paralleling the marginal row and like it extending on to the fingers; a broken row of similar low spines forms an approximately median longitudinal line, its distal portion extending on to the fixed finger. There are several irregularly spaced spines on the external surface. The entire external surface of the propodus is covered with fine close-set short setae. The margins are fringed with much longer setae. The propodal finger is quite a third wider basally than the hinged finger; both fingers thinly laminar and the inner cutting edge armed with five or six teeth each, those of the propodal finger being sharp, those of the hinged finger, rudimentary; the distal part of the cutting edge of each finger is smooth, closely fitted upon the other, the apex of the hinged finger is a denticle. The inner side of the propodus is dilated, convex, proximally tapering to a thin plate distally; there is an excavation or hiatus on the inner face between the cutting edges of the fingers formed by the excavate cutting edges which, however, meet closely and show no hiatus on the external surface.

The left cheliped is about three-fourths (or more) as large as the right and resembles it in major features, but differs from it in having the outer lateral face of the merus armed with a prominent row of eight long curved acuminate teeth on its ventral margin; also in the proportions of the propodus, the palm being scarcely one fourth of the total length, while the fingers are three-fourths the length. The contour of the inner lateral margin of the propodus is more convex than that of the large cheliped and the fingers are thicker. They have the distal portion curved slightly inward accentuating the spoon-shaped tips. There is a moderate gap between the proximal portions of the fingers and they are devoid of teeth. The left (smaller) cheliped has its external and lateral margins more densely hirsute than those of the large chela; the rounded tips of the fingers being quite brush-like.

The first and second pairs of ambulatory legs are similar and subequal, and those of the right and left sides are also identical. They exceed the length of the chelipeds by the length of the dactyl. The proximal joint is well-developed, the second joint small, the ischium is elongate projecting beyond the body in a dorsal view, and has its ventral margin rough and setigerous. The merus is long, rounded but decidedly compressed laterally; the carpus is as long as the

merus but a little less robust and has a sharp spine on its upper distal margin; the propodus is slightly longer and slenderer than the carpus; the dactyl is one and one-half times as long as the propodus and is tapering, decidedly acuminate, terminating in a sharp curved claw. There is a ventral longitudinal row consisting of six sharp horn-like spines and another row of six similar spines on the anterior lateral face of the dactyl. The upper surfaces of the carpus, propodus and dactyl are furnished with numerous long setae, these forming small tufts on the dactyl.

The paired genital apertures are circular openings on the ventral faces of the coxal joint near the base.

The third ambulatory (fourth) leg is small and has the ischium and merus subequal, curved and bent, conforming to the body contour; the carpus two-thirds as long as the merus and forming an elbow; the propodus is stout, not quite as long as the carpus, or with its maximum length only a trifle greater than its width; its posterior lateral and distal margins are confluent, rounded; the distal third of the outer surface is covered with a patch of squamae; the dactyl arises from the anterior lateral margin of the propodus and is sickle-shaped and nearly twice as long as the propodus, its posterior lateral margin a little concave, its anterior lateral margin convex, its distal third is a brown spine-like tip; both margins are fringed with setae.

The fifth pair of legs are typically small, arched proximally transversely across the body, the distal two-thirds reflexed upon itself. The distal points are chelate the finger closing completely upon the dactyl; both are covered on their external face with squamae and the finger bears a long brush of setae on its lateral margin.

The abdomen is soft, membraneous, asymmetrical, devoid of segmentation except distally. The last abdominal segment is weakly calcareous; the telson is transversely segmented and asymmetrical; the propodal portion is not quite as long as the preceding segment; the distal portion is nearly twice as long as the proximal and is transversely indented on the median lateral margin; the two lobes of the distal margin are conspicuously unequal, rounded, armed with minute denticles. The rhipidura have the elongate peduncle, the smaller branch closely appressed to the peduncle and with its convex outer face covered with squamae; the longer branch has its upper margin convex, the lower, concave, its outer surface is covered distally with squamae and both lateral margins are fringed with setae.

There are four abdominal appendages in the female, those of the second, third and fourth segments each being composed of a long basal joint, one long and one shorter distal blades the margins of which are furnished with long setae. The eggs are attached to the long hairs of these three appendages. The appendage of the fifth segment is shorter, uniramose and does not support any eggs in the present specimen which is abundantly ovigerous.

No vestige of appendages is discernible on the opposite side of these segments in the female.

Eggs.—The female described carried about 200 small pearly spherical eggs.

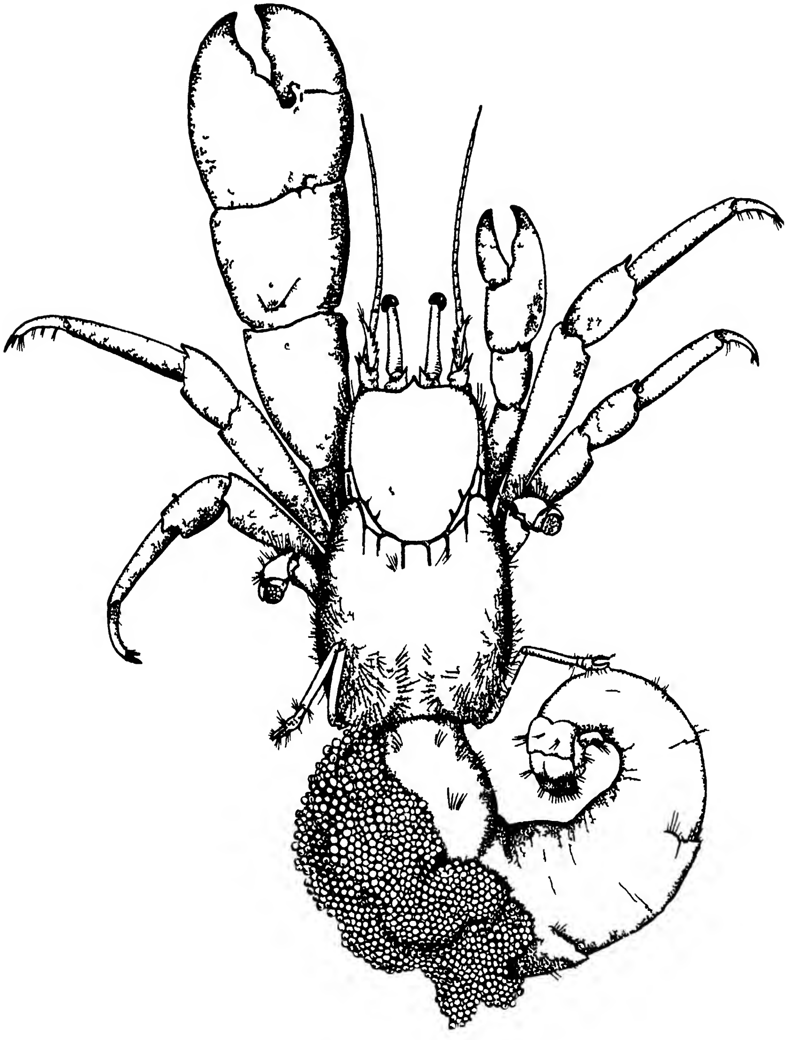

Fig 6 *Calcinus explorator* new species type much enlarged

Genus *Calcinus* Dana

Calcinus explorator, sp nov

Calcinus obscurus Schmitt (*not Stimpson*) Zoologica, N Y Zool Soc. vol 5, no 15, p 170, 1924 *Calcinus explorator* Boone, Bull Vanderbilt Marine Museum, III, p 28, pl 3, 1930

Diagnostic Characters —Great chela almost subcircular, hand wider than

long; meral and carpal joints of second and third right ambulatory legs equal or only a little longer than those of the left legs.

Type.—The type, an adult male, and four additional specimens, one of which is ovigerous, were taken at station 54, Gardner Bay, Hood Island, by William Beebe while diving in 15 feet of water. They are deposited in the collection of the New York Zoological Society.

Galapagos Distribution.—Gardner Bay, Hood Island, *Arcturus* station 54, 15 feet; Tower Island, zone H, station 37; Eden Island (Harrison Williams Galapagos Expedition).

General Distribution.—Galapagos Islands; Cocos Island.

Material Examined.—The type, an adult male specimen and four additional specimens, one ovigerous, were taken at station 54, in 15 feet of water, at Hood Island, by William Beebe, while diving. Twenty-five specimens, at least four of which are ovigerous, were taken at station 37, zone H, Tower Island, April 10, 1925. Ten specimens were taken at Cocos Island. All the specimens are deposited in the collections of the New York Zoological Society. Ten specimens of this species were secured by the Harrison Williams Galapagos Expedition at Eden Island, off Indefatigable Island, Galapagos, April 6, 1923. Six of these were referred to the United States National Museum for identification, and were identified and published by W. L. Schmitt as *Calcinus obscurus* Stimpson. The two specimens returned to the collections of the New York Zoological Society under this name are unquestionably *Calcinus explorator*, and the four specimens retained in the collections of the United States National Museum presumably are the same.

Habits.—This quaint little Pagurid appears to prefer molluscan houses that have a circular aperture which is especially suited to fit the subcircular great chela. It was discovered on coral bottom in depths ranging from the shore, along the tide-line to 2½ fms. of water.

Color.—(Alcoholic specimen) abdominal and posterior part of carapace light greenish; precervical region of carapace, great antennae and ischia of legs orange-red with tiny pearly dots; merus, carpus and propodal joints of legs deep purplish grey with microscopic, bluish, pearly dots; dactyl joints of ambulatory legs with basal and distal thirds of each orange-red, median third and spine like tip deep purplish grey. Chelae deep purplish grey shaded with rosaceous tints, tips and inner margin of fingers pearly-white. Eyestalks light purplish grey, cornea black.

Technical Description.—Approximate body length, tip of rostrum to tip of telson uncoiled, 38 mm.; carapace 10 mm. long., 9 mm. wide; great cheliped 18 mm. long.

Carapace with the frontal margin almost straight, rostral point very small, lateral projections even more obscure. Anterior region of carapace with hard dorsal plate squarish, having the margins subparallel except posteriorly where they converge slightly forming a rounded posterior margin. Lateral walls and posterior region subglobose, membraneous.

Ocular peduncles about as long as the width of the anterior border of the carapace; cornea terminal, hemispherical, ocular scale about as long as the

inner side of the basal antennal joint, sublobate, tapering to an acute point, separated from each other by a V-shaped space.

Outer antennae with basal joint about two-thirds as broad as ocular peduncle, and having outer dorsal distal angle produced acutely and finely serrate on the margin of the produced point; second joint small, ventrally placed, triangulate; third joint compressed cylindric, almost concealed dorsally by the acicle which arises from the first peduncular segment, and tapers conically to an apex, being about as long as the third peduncular article and having the inner dorsal marginal quadriserrate. The fourth peduncular article is about as long as the dorsal view of the first three taken together, slenderer, cylindrical, somewhat flattened dorsoventrally and supporting a flagellum consisting of many fine rings and extending as far forward as the base of the movable finger of the great chela.

The peduncles of the inner antennae are about as long as the eyestalks; the flagellum is triarticulate, each joint successively increasing in length distally; it is two branched, the longer stouter branch being about as long as the third peduncular article, tapering conically and consisting of about twenty-five rings and bearing a long fine brush of close-set setae on the ventral side. The shorter branch is ventrally placed, is about half as long as the upper branch and consists of ten or eleven annulations which are about the same diameter as the distal annulations of the upper flagellum.

The left cheliped is much larger than the right and has the basis and ischium quite small, only the outer distal angle of the latter being visible in a dorsal view, the merus is three-sided, bent to fit the space between the body and the ambulatory leg, and has the dorsal surface broad and curved; the carpus is a trifle shorter than the merus, is much narrower basally, outwardly convex and broadening distally to form a close union with the propodus, the inner distal angle of the carpus is produced into a tiny interlocking point and the outer distal angle of the carpus is similarly produced and its lateral contour slightly ridged. The propodus is subovate, almost subcircular, its diameter, taken at the base of movable finger, is slightly greater than long diameter, taken from the inner basal angle of the movable finger obtusely truncates the hand, being practically an unbroken line save for the minute median depression into which the basal tooth of the movable finger fits. This line and the placing of the fingers is distinctly different from that of *Calcinus chilensis* Milne Edwards, which Stimpson says his species *Calcinus obscurus* is like, "except for the absence of tubercles on the chela." The movable finger of the present species has the outer margin curved, the apex occurring at the outer lateral margin, the inner margin fitting closely upon that of the fixed finger. The fingers open obtusely; their distal ends are neatly spoon-shaped and the meeting surfaces of the fixed finger crenulated, indicating 14 teeth along the outer margin of the meeting surface; the inner margin of this surface of the finger is set with five clusters of brush-like setae, the largest and innermost one being opposite the basal great molar, the remaining four being subequal, the distal two being almost beside each other. The movable finger is similarly crenulated, indicating seven teeth of moderate size and three much larger ones adjacent to the base: inside these

teeth are placed a patch of setae at the base of the hinge, followed by a row consisting of seven subequal and subequally spaced tufts of setae.

The right chela is much smaller than the left, has the meral and carpal joints less swollen, narrowed, and the hand and fingers a miniature replica in contour of those of the left chela but the fingers are more broadly spoon-shaped.

The first and second ambulatory legs are subequal; those of the right side having the meral and carpal joints equal in young or only a very little longer in large adults than those of the left side, this being another item in which the present species differs from *Calcinus chilensis* Milne Edwards and *Calcinus obscurus* Stimpson, in which the above discussed joints of the right legs are described as being much longer than those of the left legs.

The third ambulatory legs are short, flattened, curved to fit the body contour and have the upper and lower margins of all joints densely fringed with long feather-like setae. The broad subovate "fixed finger" of the terminal joint is lamellar and has the outer surface mosaiced with squamose golden yellow scales. A row of these squamosities on the outer surface of the movable finger parallels the margin of the meeting surfaces.

The fifth legs are longer, slenderer, less lamellar and more cylindrical than the fourth pair; they have the basal four joints arched to fit the body; the propodus is no wider than the carpus and is about one-fourth longer; the finger is about one-fourth of the length of the propodus; the propodus on the upper and distal three-fourths of the outer surface bears a patch of golden yellow squamosities and the hinged finger bears a longitudinal row of these, paralleling its inner margin. The carpus and especially the propodus and dactylus bear clusters of long setae but these, while abundant and close-set, stand out more individually than do the feathery hair-masses on the fourth legs. The paired circular genital apertures of the male are situated on the ventral surface of the coxal joint of the fifth legs; the paired genital apertures of the female are located on the ventral surface of the second pair of ambulatory legs.

The abdomen is tough, membraneous, asymmetrical, coiled and tapering; the telson is terminal, the abdominal segments are calcified. The last abdominal segment is squarish, the telson is transversely segmented, has the anterior portion deeply channeled longitudinally in the median area, with the posterior margin somewhat rounded at the lateral angles; the posterior portion is a trifle longer than the anterior and is very convex dorsally; there are two incisions in this joint at the basal lateral angle, another two near the distal angle and one in median distal margin; these incisions and their attendant depressions enhance the convexity of the distal portion of the carapace and insure its fitting into the molluscan shell. The lateral and posterior margins of the proximal joint of the telson are sparsely setose and those of the distal joint are continuously fringed with setae. The rhipidura have the basal joint, which arises from proximal half of the telson, curiously produced and curved, marked with a slight incision at the base of the smaller branch, and with a deep crooked depression at the base of the larger branch. The smaller branch which is closely appressed to the basal joint, has its lower margin arcuate and the upper one curved. The outer surface of the distal part is covered with a patch of golden

yellow squamosities like those on the smaller branch. Both branches are fringed with long feather-like setae.

The third, fourth and fifth segments of both sexes bear pleopoda on the left side. These are situated at the outer anterolateral margins of the segment and are subequal. Each pleopod consists of a long lamellar base which bears paired lobate branches; the posterior branch is about as long as the base, not quite so wide, oar-blade shape and fringed with feathery setae which average about one and one half times as long as the branch itself; the anterior branch is slightly wider and nearly twice as long as the posterior branch and has its forward margin more convex than its posterior margin. There are no appendages on the right side of the abdomen but a tuft of setae occurs at the spot opposite the pleopoda of left side. The female pleopoda are more developed than those of the male.

A female about 27 mm. long was taken carrying about 506 eggs. These are very minute, less than 0.5 mm. long diameter, ovoid, creamy ivory, encased in an opalescent transparent membrane. The second and third pleopoda are reflexed over the back and the branches spread wide apart, the long setae serving as accessories to which the eggs are attached like miniature grapes. The eggs borne by the second and third pleopoda are well-spaced, seldom touching each other and never more than two layers deep. The anterior pleopod is also reflexed over the back but it reaches so far forward that the eggs are in part packed in the crevice existing between the carapace and first abdominal segment and in part extruded from the molluscan aperture. The most anterior eggs are packed three or four layers deep. The most posterior pleopoda do not support any eggs.

Family COENOBITIDAE

Key to the Galapagan genera of the Family COENOBITIDAE

Chelipeds markedly subequal, the left the larger. Carapace elongated. Rostrum slightly marked. Abdomen soft, membraneous, twisted on itself; sixth abdominal segment and telson well defined (land hermits) *Coenobita*

Chelipeds subequal, fingers moving in a horizontal plane, corneous at the tips, spoon-excavate. Carapace with a small tooth-like rostrum (marine hermits) .. *Clibanarius*

Genus *Coenobita* Latreille.

Coenobita compressus (Guerin). Land hermit. Flat-eyed hermit.

Coenobita compressus (Guerin), *Voy. autour du Monde sur la Coquille par Duperrey, Zool., vol. 2, pt. 2*, p. 29, 1831.

Coenobita compressus Faxon, Mem. Mus. Comp. Zool. vol. 18, p. 52, 1895; Rathbun, Proc. U. S. Nat. Mus. vol. 38, p. 596, 1910; Schmitt, Zoologica: New York Zoological Society, Vol. V, p. 170, No. 16, 1924.

Diagnostic Characters.—Eyestalks decidedly compressed laterally. Inner face of propodal joint with a subcrescentic band of silky setae on the upper proximal part, the distal setae bordering the upper propodal margin.

Fig 7 *Coenobita compressus* (Guerin) natural size.

Type.—M. Guerin's type material came from Payta, Peru, and is probably deposited in the Paris Museum.

Galapagos Distribution.—Indefatigable Island, one male in shell of *Nerita scabricosta* (*Albatross*); South Seymour Island (*Arcturus*).

General Distribution.—Acapulco, Mexico; Galapagos Islands, Cocos Island and Payta, Peru; westward to East Africa.

Material Examined.—Two male specimens from South Seymour Island, also four males and five females one of which is ovigerous from Cocos Island intertidal zone, were taken by the *Arcturus* Oceanographic Expedition. One male, one ovigerous female, also the abdomens of two more ovigerous females were taken at James Island, April 4, 1923 by the Harrison Williams Galapagos Expedition.

Habits.—This species inhabits the intertidal zone, and was also found as

far as a quarter of a mile inland on James Island by Dr. William Beebe, who observed it skittering about among the moist detritrus of the woodland floor. The prevalence of ovigerous females taken on the intertidal zone of Cocos Island, May 19, 1925 and on the shore of James Island, April 4, 1923, indicate that this is the dominant breeding season.

Technical Description.—Approximate body length, tip of rostrum to tip of telson uncoiled, 57 mm.; carapace 15 mm. long, maximum width 11 mm.; great cheliped 34 mm. long.

Carapace with the frontal margin about straight, rostral point absent; lateral projections small, pointed. Anterior region of the carapace subrectangular, slightly wider posteriorly dorsal surface slightly convex and covered with scale-like imbrications which are smaller anteriorly, nearly absent in the outer and much larger on the posterior half which region also bears numerous fine setae. The posterior region of the carapace is decidedly convex, with a hard, hourglass shaped median calcareous plate, to which are closely fused the paired, suboval, calcareous plates which cover the greater part of the dorsal surface. These plates are harder on the anterior and inner regions but pass almost imperceptibly into a tough, semicalcareous reticulated membrane on the outer and posterior parts.

The abdomen is asymmetrical, coiled and tapering encased in a very tough, leathery membrane; the first four segments are clearly indicated; there is a harder, central suboval median patch between the second and third segments—also another between the third and fourth segments; the penultimate segment bears a subquadrate calcareous plate on its dorsal surface. The telson is small, transversely bent; the basal joint of the rhipidura is nearly as strong as the larger blade which latter bears a large ovate patch of brown scales and is fringed on the margins with long silky setae; the inner blade is quite small, scarcely reaching to the distal end of the basal joint, and bearing a patch of scales on its own distal region.

The female bears three biramose appendages which arise from the anterior lateral margin of the left side of the second, third and fourth abdominal segments respectively. The most anterior appendage is the smallest, the median appendage is the longest and the posterior one is slightly shorter. Each appendage has both blades fringed with long silky setae. There are rudimentary indications of the second and third appendage on the right side. In the male there are rudimentary indications of appendages on both sides of the third and fourth segments.

The ocular peduncles are about as long as the anterior margin of the carapace and are strongly compressed, and excavated on the proximal part of the inner faces for the reception of the inner antennae when retracted; the outer surfaces are similarly excavated on the lower half to afford space for the peduncular joints of the external antennae while on the upper half they are exceedingly thin but convex, and covered with rough, scale-like granulations; the upper distal margin is slenderly produced above the cornea and is also covered with rough scales. The cornea is terminal, exceedingly compressed, shielded on the upper and inner faces by the produced eyestalk, with the distal surface very

narrow and the outer surface triangulate and but little convex. The ocular scale is triangular, the two are set close together and extend about one-third of the length of the ocular peduncle.

The external antennae have the peduncular articles laterally compressed; the first article is subcrescentric, produced on its upper surface into an acute process which reaches to the base of the third joint; the second joint is very small and is ventral in position; the third joint is small, compressed, about as broad on its outer side as long; the fourth joint is also compressed and is about as long as the eyestalk; the flagellum is composed of sixty-five short stout rings, each of which bears a series of short, stiff setae on the distal margin.

The inner antennae have the basal articles enlarged and produced into a crest on the upper proximal surface, the distal portion slender; the second and third articles are long, slender, subequal, compressed rods; the flagellum is biarticulate, the proximal half of the longer branch consists of ten rings; the distal half of the flagellum is one long articulation which is constricted on its upper surface simulating annulations; its lower third is defined from the upper two-thirds by a longitudinal groove. The distal end is furnished with short, soft, silky setae on its lower edge. The inner antennae are four-fifths as long as the outer antennae. When retracted the former pair fold upon themselves and fit between the eyestalks.

The chelipeds are similar, the left one being substantially larger than the right. Each has the proximal joints small but strong; the meral joint is extremely compressed laterally with distal part trigonal, the anterior distal face triangulate and imbricated, the upper inner margin terminating distally in an acute tooth, while the outer lateral margin especially of the larger chela is produced into a rough imbricated process. The carpus is short and stout, trigonal, with the outer surface convex and imbricated especially along the inner margin. The hand is as broad proximally as its greatest length, from the propodal base to the tip of the propodal finger; the outer surface is convex, the lower proximal part is produced into a rounded, laminar lobe; the outer surface is covered with scale-like imbrications. The propodal finger is short, stubby and blunt, set with one large subdistal tooth. The hinged finger is only two-thirds as wide basally as the propodal, is stout, set obtusely and slightly gaping, blunt distally and armed on the inner surface with two teeth; the outer surface is covered with scale-like tubercles.

The second ambulatory legs are longer than the first pair by one third the length of the dactyl. Both the first and second pairs have the meral joints decidedly compressed, that of the first leg being flattened on both sides, while that of the second leg is a little thicker and is convex on the outer surface and covered with squamosities; the carpal joint of the first leg is slightly shorter than that of the second, its inner face is flattened, the upper face is slightly convex, the outer lateral face is much narrower than the others and is flat and thickly set with squamosities which become very coarse and sharp along the inferior lateral margin; the carpal joint of the second leg is slightly longer than that of the first and less pronouncedly trigonal, the outer and under faces merging without a ridge; the dactyli are the longest joints of the respective append-

ages, that of the second being almost a third longer than that of the first; both are stout, curved, covered with small squamosities and set with small tufts of short bristles. The third pair of ambulatory legs are typically modified, being closely appressed to side of posterior region of the carapace; the meral is the largest, being broad, almost subovate; the carpal joint is somewhat smaller, squamose on its outer surface and fringed with long silky setae along its anterior margin; the propodus is subchelate, suboval, covered on the outer surface, except for a small basal area with squamose, brown scales; the margin is fringed with long silky setae; the finger is very small, squamose and setigerous, situated on the proximal anterior part of the palm.

The fifth pair of ambulatory legs are slender, short and subcylindrical with the distal third folding back upon the proximal part; the large curved, paired male appendages arise from the coxal joints and are nearly as large as the remainder of the leg. The appendages are strong, lie close together and are strongly arched; they are pointed at the tip which is covered with silky brown setae. The ischium of the fifth leg is short, the merus is long, subcylindrical, the carpus is about two-thirds as long as the merus; the "palm" of the propodus is as long as the carpus; the finger is three-fourths as long as the palm and is spatulate. The outer face of the palm bears an ovate patch of brown scales and the remaining faces of the palm and both fingers are covered with silky brown setae.

Genus *Clibanarius*

Clibanarius chetyrkini, sp. nov.

Name. It is a pleasure to name this species for Mr. Serge Chetyrkin, preparator of the Tropical Research Station of The New York Zoological Society.

Type. Three male specimens were taken at station 54, Gardner Bay, Hood Island, Galapagos, by William Beebe while diving in fifteen feet of water.

Galapagos Distribution. –*Arcturus* station 54, Gardner Bay, Hood Island (type-locality).

General Distribution.—Known only from the Galapagos Islands.

Material Examined. - Three males from *Arcturus* station 54, Gardner Bay, Hood Island, Galapagos Islands.

Technical Description. –Approximate body length, tip of rostrum to tip of telson uncoiled 39 mm.; carapace 13.5 mm. long, 5 mm. wide at frontal border; great cheliped 11.5 mm. long.

Carapace with the frontal margin sinuous, rostral point well developed, triangular, acuminate, submedian projections less pronounced. Anterior region of carapace covered with a calcareous plate both on the dorsal and lateral surfaces. Posterior region subglobose, membraneous, with a slight irregular calcareous element along its anterior dorsal and lateral margins. There are several tufts of long spine-like setae regularly placed along the anterior border of the posterior region of the carapace. Similar but much narrower tufts are regularly spaced forming rows on the remainder of the posterior region while on the lateral parts of the anterior region of the carapace there are wide tufts of

Fig. 8. *Clibanarius chetyrkini*, new species, type ×3

long spine-like setae and the dorsal surface is sparsely set with short, irregularly placed setae.

Between the bases of the second ambulatory legs there is a short transverse calcareous bar and just anterior to the latter there is a longer but much narrower process which has the anterior margin rounded and setiferous. Between the

bases of the third ambulatory legs there is a slender transverse bar which has the anterior margin setiferous.

On the ventral thoracic surface just about midway between the last mentioned transverse bar and the bases of the fifth legs there are a submedian pair of rounded, calcareous process's each of which arises from the softer membrane and has its entire edge fringed with long stiff setae.

The abdomen is membraneous, asymmetrical, coiled and tapering. The last abdominal segment is subrectangular with its anterior margin a little rounded and is calcareous like the telson and has a distinct slightly depressed median dorsal line, also a pair of submedian tufts of stiff setae.

The abdominal appendages of the second, third, fourth and fifth segments, four in number, are on one side only in the males (females unknown). Each appendage consists of a well-developed base, a long, narrow ovate anterior branch and a rudimentary posterior branch which is neither quite as long nor as wide as the peduncular joint; both branches are fringed with long, rather stiff, brownish black setae.

The telson is transversely segmented, the proximal part being subrectangular consisting of two convex lobes separated by a decided median depression and also having the two lesser submedian depressions on the distal half; the terminal section is asymmetrical with two transverse incisions on the lateral margins and one incision in the median distal margin; the posterior margins of both sections of the telson are fringed with long setae.

The rhipidura are typical of the members of this genus, with a substantial, curved, calcareous base armed with spinose setae, a short, button-like outer branch, the external face of which is covered with close-set scales and a longer branch which also has a large patch of scale-like squamosities on its outer surface.

The ocular peduncles are cylindrical, slightly dilated at the base, set with small tufts of setae on the upper and outer surfaces; the cornea is terminal, subspherical, composed of many minute hexagonal facets; the proximal margin is sinuate. The eyestalks are about as long as the width of the anterior border of the carapace; they reach almost to the distal end of the antennulae. The ocular scales are separated from each other by a space equal to the basal width of one scale; each scale is triangular, 5 mm. wide at the base and 1 mm. long, with an acuminate apex.

The peduncles of the antennulae are slender, compressed cylindrical and reach almost to the cornea; the flagellum is biramose, the inferior branch being about three-fifths as long as the superior branch on its lower face.

The external antennae have the first joint trigonal, produced to a distal acuminate point on both the upper and lower outer lateral margins and with several long spinose setae at both the outer and inner dorsal lateral angles. The first segment supports the acicule, is irregularly triangular, heavily set with spine-like hairs on the dorsal surface and tapering to an acuminate point distally. It almost entirely covers the third segment. The second and third segments are small, the second being quite ventral in position while the third is beneath the

acicule; the fourth segment is about as long as the first three taken together and is quite slender, compressed cylindrical; the flagellum consists of about fifty-four rings and reaches to midway the propodus of the cheliped.

The external maxillipeds are closely approximated.

The chelipeds are equal in the male. They have the proximal joints small but well developed; the merus is long, curved, wide laterally but decidedly compressed, the dorsal edge being sublinear and heavily set with tufts of setae. The upper and outer surfaces of the merus are broken by a subdistal transverse line simulating segmentation; the lower lateral portion of this area is bisected by a short, longitudinal line. The carpus is curved, thick, nearly as long on its dorsal face as the palm of the propodus from which it is rather difficult to distinguish, the articulation being almost imperceptible. The propodus is 6 mm. long and 3.5 mm. wide at base; the palm is 3 mm. long, the hinged finger is also 3 mm. long. The propodus is stout and quite thick and tapers slightly toward the distal end which is broadly rounded. The two lateral and the dorsal surfaces of both the propodus and carpus are covered with large conical tubercles each of which arises from the approximate outer of one of the white maculations; each tubercle is fringed anteriorly by a semicircle of bristly stiff blackish brown setae. There are also a few single long black setae irregularly arising from the white maculations. These long hairs are more abundant on the carpus.

The propodal finger is slightly wider at the base than the hinged finger which latter bears a strong, interlocking proximal tubercle on the dorsal (outer) surface. Both fingers fit closely upon each other; the fixed finger has its proximal lobe overlapping the base of the hinged finger and following this there are three unusually well-developed molars along the cutting edge, the tips are decidedly rounded, deeply spoonshaped, and have the distal margin with a deep rim of brown corneous substance. Inside the concavity of each finger there are two tufts of setae, and along the inner lateral margins of each finger there are similar tufts of setae.

The first and second ambulatory legs are similar and subequal, they are each a trifle longer than the cheliped. The merus of the first leg is long, curved, decidedly compressed except the upper distal area which is slightly thicker; the upper dorsal surface bears a longitudinal series of tufts of long stiff setae; the carpus is about two-thirds as long as the merus and is much more robust. It has several longitudinal rows of tufts of stiff setae; the propodus is a trifle longer than the carpus but is more compressed cylindrical and has more long tufts of setae on the dorsal surface; the dactyl is well-developed, curved, with the outer surfaces a little convex, a sharp horny spine at the tip; the dorsal and ventral faces are each set with a longitudinal series of very long coarse tufts of setae. The second leg is very similar to the first except that it has the outer side of the merus moderately convex instead of flattened.

The fourth pair of legs are typically small and fitted close to the sides of the body. The first, and second, and third proximal joints are flattened and curved to fit the body; the merus is also wide and flattened and is nearly twice as long as the ischium; the carpus is about two-thirds as long as the merus and forms a decided elbow with its outer lateral margin armed with several tufts of long

setae; the propodus is about as long as the carpus and is broadly rounded on its posterior lateral margin; it is decidedly chelate, the dactyl forming a slender curved finger which fits closely upon the thicker propodal finger. The distal three-fourths of the outer surface of the propodus is covered with golden-yellow squamae.

The fifth pairs of legs is small, well separated from the preceding pair and in the male, modified for sexual purposes. There is a strong V-shaped calcareous arch beneath the legs with its apex thickened and projecting from beneath and between the coxal joints; it has a stiff brush of setae on its anterior margin, as have also the coxal joints, which bear the paired, rounded, genital apertures. The basis is small; the ischium is much longer, the merus is about one-third longer than the ischium; the carpus is about two-thirds as long as the merus; the propodus is nearly as long as the merus and has its outer lateral margin decidedly curved and its upper surface decidedly convex and with a large suboval patch of squamae on the distal area; the dactyl is small, terminal, covered on its upper surface with squamae and nearly hidden by a long brush of golden setae which arise at the base of the finger and are twice as long as it is. The finger fits so closely upon the propodus that it is difficult to distinguish it. There are tufts of delicate long setae on both lateral margins of the merus, carpus and propodus also.

Family PORCELLANIDAE

Key to the Galapagos genera of the Family PORCELLANIDAE

I. Lateral walls of the carapace (epimera, or sub-branchial region) entire. Chelipeds equal or nearly equal, broad, flattened; carpus elongate *Petrolisthes*

II. Lateral walls of the carapace with the *linea anomurica* clearly defined. Chelipeds decidedly unequal, broad, stocky, convex dorsally; carpus short *Pisosoma*

Genus *Petrolisthes* Stimpson

Key to the Galapagos species of the Genus *Petrolisthes*

I. Carpus of chelipeds with the anterior lateral margin cut into three or more prominent teeth; dorsal surface of carpus very rough, covered with transverse rugae.

   A. Anterior lateral margin of carpus of chelipeds armed with three shallow teeth; merus of first and second ambulatory legs with one subdistal spine on posterior lateral margin; no such spine on merus of third ambulatory leg. Lateral margin of carapace terminating anteriorly in a sharp hepatic spine...... .... *armatus*

   B. Anterior lateral margin of carpus of chelipeds armed with three large, deep serrated teeth and several minute ones; merus of first, second and third ambulatory legs, three-fifths as wide as long, set with a series of sharp spines on the anterior lateral margin. Carapace and chelipeds covered with large transverse scale-like rugae which are fringed

anteriorly with setae; three grooves on the carapace form an equilateral triangle with the apex directed posteriorly *edwardsii*

C. Anterior lateral margin of the carpus of chelipeds cut into six large serrate teeth each of which has the margins finely denticulate; dorsal surface of carpus crossed by a series of prominent oblique rugae. Merus of first, second and third ambulatory legs twice as long as wide, crossed by a series of transverse rugae, each ruga terminating at each lateral margin in a sharp small spine. Carapace but little convex; lateral margin delineated by a sharp line which terminates anteriorly in a sharp hepatic spine; a second, similar spine occurs a little above the lateral line and almost as far behind the hepatic spine as the latter is from the postorbital spine. Entire surface of carapace covered by strong, unbroken, transverse rugae which are equally prominent on the anterior, median and posterior regions of the carapace. Distal pair of sutures of the telson oblique *amoenus* (Guerin)

D. Anterior lateral margin of carpus of chelipeds cut into five acute triangular teeth, each of which has its margins denticulate; a series of about six prominent, rounded squamae form a median ridge on the dorsal surface of the carpus, smaller granules are scattered in the remaining dorsal area. Carapace convex in both directions; lateral margins delineated by a line which terminates anteriorly in a single sharp hepatic spine. Dorsal surface of carapace devoid of rugae except for one pair of wide transverse rugae on the anterior part of the gastric region; carapace minutely, sparsely granulose and finely hirsute. Distal pair of sutures of the telson oblique *galathinus* (Bosc)

II. Carpus of chelipeds with the anterior lateral margins not cut into teeth; dorsal surface of carpus never very rough; granulose or finely tuberculate.

A. Carpus of chelipeds two-thirds as wide as long; lateral margins slightly convergent distally; the anterior proximal angle produced to a prominent rounded lobe; the dorsal surface is granulose, the granules being coarser and thicker along the posterior lateral margin where they form a submarginal ridge which terminates distally in a prominence; there also is usually a similar median ridge on the proximal half of the carpus. The carapace is longer than wide; slightly convex longitudinally; deeply areolated, finely granulose, with the branchial regions finely striated transversely. The distal pair of sutures of the telson are oblique. The external maxilliped has the inner lateral margin of the merus produced into a prominent rounded lobe *cinctipes*

B. Carpus of chelipeds one and three-fourths to twice as long as wide, lateral margins parallel; inner proximal angle rounded but not produced; dorsal surface finely, irregularly granulose and minutely punctate; areolations distinct, branchial regions lightly striated transversely. The distal pair of sutures of the telson are nearly transverse. The external maxilliped has the inner lateral margin of the merus produced to a broad rounded lobe; the distal extremity of the ischium is rather truncated and rounded *eriomerus*

Fig 9 *Petrolisthes armatus* (Gibbes) X 3

Petrolisthes armatus (Gibbes). Elfin crab.

Porcellana armata Gibbes, Proc. Amer. Assoc. Adv. Sci. vol. 3, p. 190, 1850.

Porcellana gundlachii Guerin, in La Sagra's Hist. Cuba, vol. 8, (atlas), Articulata, pl. 2, fig. 6, 1855.

Petrolisthes armatus Rathbun, Proc. U. S. Nat. Mus. vol. 38, p. 558, pl. 41, fig. 3, 1911. Boone, Bull. Vanderbilt Marine Mus. III p. 73, pl. 19, 1930. (With comprehensive synonymy.)

Diagnostic Characters.—Carpus of cheliped about twice as long as wide; armed with three shallow teeth on anterior margin; merus of first and second ambulatory legs with one subdistal spine on posterior lateral margin; no such spine on merus of third ambulatory leg. Lateral margins of carapace terminating anteriorly in a sharp distal (or hepatic) spine.

Type.—Gibbes' type material, which came from the West Indies, is deposited in the Academy of Natural Sciences of Philadelphia.

Galapagos Distribution.—Two specimens of this species taken at Eden Island, April, 1923, appear to be the first Galapagan record for this well known species.

General Distribution.—From southern Florida southward through the West Indies and Bermudas to Brazil; from Lower California southward, including the Galapagos Islands, to Peru; the Indo-Pacific region.

Technical Description.—Carapace 8 mm. long, 10.5 mm. maximum width; moderately convex; surface covered with flattish broken transverse rugae which are more prominent on the lateral branchial regions. Rostrum broadly triangular with a distinct but shallow median depression; frontal margin slightly sinuate and finely crenulated; the superior orbital margin is unbroken. The lateral margins are carina-like and terminate sharply in a sharp postorbital spine. The hepatic sinus is shallow but distinct. The anterolateral or postorbital angle is almost right angled. There are a pair of wide transverse ridges slightly separated from each other by the median groove, which taken together form a prominent postrostral transverse groove across the anterior gastric region. The abdomen is composed of six segments of which the anterior three are dorsally visible, the remaining segments being loosely flexed under the body. The first segment is but little more than half as wide and long as the second and has its antero-lateral margins narrowly rounded, its postlateral margins convergent; the second, third, fourth and fifth segments are subequal, each has its lateral margin separately rounded and heavily fringed with long plumose setae; the sixth segment is narrower than the fifth and has its lateral process slenderly acuminate and narrow, excavate for the reception of the peduncle of the rhipidura. The telson is subtriangular with the lateral and posterior margins rounded; it consists of a short proximal median triangular plate which has the lateral contour sinuate; and a pair of lateral lobes which surround and project beyond the median plate; each lateral lobe is transversed by a pair of sinuate sutures which extend from opposite the inner distal margin inward to the suture around the median lobe; there is also a posterior pair of sutures which extend inward a little obliquely to the median membraneous area which is just posterior to the apex of the median proximal plate; this median membraneous area continues as a median line separating the lateral lobes; there is also a clear cut median incision separating the convex-margined lateral lobes. Thus the telson is composed of a proximal median plate which is surrounded by two lateral lobes, each of which is broken by sutures into three parts, giving the telson the appearance of being composed of seven plates. The rhipidura have the peduncle broad and short with its outer margin cut into three unequal lobes of which the most anterior is small and acuminate; the median larger and subangulate; the posterior, as large as the other two taken together and broadly rounded; the inner blade is longer and is elongate—oval with its distal margin broadly rounded, finely crenulate and heavily fringed with long plumose setae; the outer blade is slightly shorter, oval and has its outer lateral margin more convex than that of the inner blade; the outer blade is also crenulate on the margin and heavily fringed with long setae.

The female abdominal appendages consist of three pairs, which respectively arise from the third, fourth and fifth abdominal segments; each branch is uniramose, consisting of a longish peduncle and a longer tapering branch which is furnished with several heavy limb-like setae to which the clustered eggs are at-

tached. The first pair of appendages are quite short, the second pair about a third longer than the first pair, while the third or posterior pair are nearly twice as large ars the first pair.

The chelipeds are slightly unequal, the left being the larger. Each cheliped is broad and flat, with the three proximal joints small, the merus short and broad distally, trigonal, with a single small spine on its posterior distal margin, also a small spine on its ventral anterior distal margin; there is also a subdistal, curved, transverse ruga on the dorsal surface of the merus; the carpus is three-fourths as long as the maximum width of the carapace or about twice as long as its own width and is trigonal, its upper surface being relatively flat and covered with small rugae; the anterior margin is armed with three teeth; the distal dorsal margin is sinuate, armed with two or three spines; the dorsal posterior lateral margin is accentuated by a longitudinal series of six or seven forward-pointing spines; the anterior lateral face of the carpus is slightly excavate so that the reflexed propodus fits closely into it; the posterior lateral face of the carpus is convex; the propodus is very large, being 17 mm. long, or twice as long as the carpus, the palm comprising two-thirds of this length. The palm is triangular, widening distally; the outer surface is flat, covered with small crimson rugae; the propodal finger is triangular with the tip upcurved, the cutting slightly carinate and sinuate. The hinged finger is subequal to the propodal finger but has a decided submarginal groove paralleling its upper lateral margin. The left cheliped has its propodal finger narrower than that of the right cheliped and its hinged finger much broader basally. There is a distinct gape between the fingers of the left cheliped, the propodal finger also having a slight excavation near its distal end and its apex not upcurved; the tip of the hinged finger is curved and convex subdistally.

The inner depressed area of the cutting edge of both the hinged fingers also the basal area of the propodal fingers is densely pilose; these hairs forming a short velvety brush which is rot visible in an external view of the chelipeds.

The first, second and third pairs of ambulatory legs are similar; the first and second pairs are subequal in length; the third being shorter, reaching only to midway the propodus of the second pair. Each leg has the merus broad, one-half as wide as long, with the anterior lateral margin armed with three or more spines and fringed with plumose setae; the posterior lateral margin of the first and second legs is armed with a sharp subdistal spine which is absent on the third leg; the carpus is a little more than half as long as the merus and is much narrower; it is convex dorsally, widening a little distally and the upper distal angle is roundly produced; the propodus is about as long as the carpus but is much slenderer and is produced distally on its posterior lateral margin into a rounded process which reinforces the dactyl joint; the dactyl is slightly more than half as long as the propodus and is stout and curved with an acuminate tip. The four distal joints of these legs are well furnished with tufts of setae; also few plumose setae.

The fifth pair of legs are characteristically small, slender, reflexed and chelate. The merus is very long, the carpus almost as long as the merus but slenderer and furnished with a brush of setae on the inner distal margin; the propodus is

scarcely two-fifths as long as the carpus and the subequal spoonshaped fingers comprise a third of this length; the propodus and closed fingers are cylindrical and covered with stiff setae; the apices of the fingers are broadly rounded.

The eyestalks are short, stout, constricted below the cornea and produced distally on the dorsal surface into a rounded process which projects on the cornea; the cornea is large, elliptical.

The inner antennae have the basal article greatly enlarged and with the distal half produced into a lobate-lanceolate process which has the outer surface excavate and the distal margin crenulate; the inner distal angle is notched for the reception of the second joint and just outside this the distal margin is produced into an acuminate process which is separated from the larger outer distal margin by a V-shaped sinus; the second and third articles are long, slender, cylindrical, the second being slightly longer than the third and dilated distally; the flagellum is biramose, both branches being short; the inferior branch consists of a stocky basal joint and four minute tapering joints; the superior branch is slightly longer, is stouter and is as long as the preceding peduncular joint and is composed of numerous short tapering rings and furnished with a heavy brush of plumose setae on the ventral-lateral face.

The external antennae have the basal article short and produced on its anterior lateral margin into an oval process which bears midway its anterolateral margin, a sharp spine; the second joint is cylindrical, equal or a trifle longer than the first joint and with the anterolateral margin roughened with tubercles and having one larger triangular tubercle a little more proximal and median. The third joint is only two-thirds as large as the preceding one and is convex-cylindrical, the flagellum is 23 mm. long, reaching to midway the propodus and consisting of numerous short subequal annulations.

The external maxillipeds are very large; when extended they reach almost to the distal end of the carpus of the great cheliped. The exognath is well developed and bears a flagellate whip, the ischium of the endognath is dilated distally, broadly oval, on the inner and distal margins but with the external lateral margins diagonal; the merus is almost as long as the ischium but much narrower and with the inner lateral face channeled, the inner margin ridge-like and bearing a brush of long plumose setae; the outer edge of the channel is greatly produced into an ovate-lanceolate process, is forward and upward-directed and into which the flexed basal joint of the palp fits; the palp has the basal joint as long as the merus, triangulate, with the inner lateral margin channeled; the second article is as long as the first; triangulate, wide at the base and furnished with an exceedingly long brush of fine plumose setae on the inner lateral margin, the third joint of the palp is small, triangulate, scarcely half as long as the second joint, tapering to a blunt point; fringed on its inner lateral and distal margins with long, plumose setae which combine with those of the preceding article in forming a long brush; the outer lateral margin of the distal joint is furnished with a close-set series of short stiff setae.

Eggs.—The above described female is carrying about 75 eggs; each egg is ovoid, 5 mm. long diameter, 3 mm. short diameter.

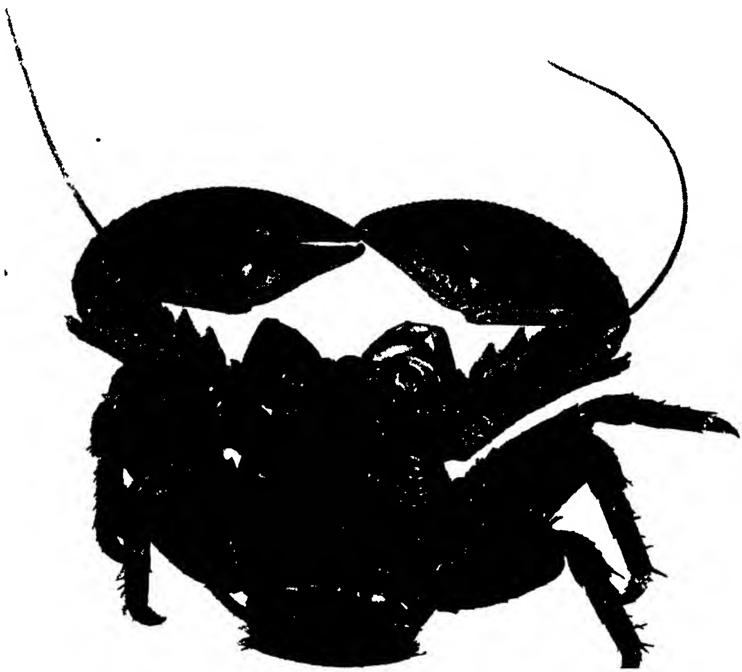

Fig. 10 *Petrolisthes edwardsii* (Saussure) ×3

Petrolisthes edwardsii (Saussure). Scarlet Tissue Crab.

Porcellana edwardsii Saussure, Rev. et Mag. de Zool., ser. 2, vol. 5, 1853, p. 366, pl. 12.

Petrolisthes edwardsii Nobili, Bull. Mus. Torino, vol. 16, no. 415, p. 11, 1901. Rathbun, Proc. U. S. Nat. Mus. vol. 38, p. 600, 1910.—Zoologica: N. Y. Zoological Society vol. V, no. 15, 1924.

Names.—This species was named in honor of Professor Milne Edwards. It is also known as the "scarlet tissue crab."

Diagnostic Characters.—Vivid scarlet; carapace and chelae covered with transverse scale-like rugae which are fringed anteriorly with setae; three lines on carapace forming an equilateral triangle with apex directed backward.

Type.—The type of this species came from Mazatlan, Mexico and is quite probably deposited in the Museum d'Histoire Naturelle, Genève.

Galapagos Distribution.—Eden Island, Harrison Williams Expedition; *Arcturus* Station 54, off Hood Island, 15 feet.

General Distribution.—Known from the Gulf of California, southward to Ecuador; also at the Galapagos Islands.

Material Examined.—Eighteen specimens from *Arcturus* station 54, off Hood Island, obtained by William Beebe, while diving in 15 feet of water. Two specimens obtained at Eden Island, rock pools, by the Harrison Williams Galapagos Expedition.

Technical Description.—Carapace 9 mm. long, 8 mm. wide, moderately convex, surface decidedly broken with transverse scale-like rugae, each of which is fringed on its anterior border with stiff setae. Rostrum triangular with the margin finely crenulate and with a decided median longitudinal groove extending backward on to the gastric region and bifurcating the median two of the four ridges or lobes which taken together form a prominent postrostral transverse rugae across the anterior gastric region. A pair of diagonal grooves pass inward from just before the postorbital spine converging anterior to the cardiac region. These three grooves form an approximately equilateral triangle with the apex directed posteriorly. The lateral margins are clearly delineated and terminate anteriorly in a sharp postorbital spine. The superior orbital border is defined anteriorly by a rounded excavation and its external angle is almost right-angled. The side walls of the carapace are covered with broken scale-like rugae. The abdomen is composed of six distinct segments of which the first is shorter and narrower than the four succeeding segments which are approximately subequal and have their lateral margins separately rounded and fringed with setae; the sixth segment is one third longer than the fifth, but distinctly narrower; the anterior lateral angle is strongly acuminate below which the lateral margin is excavate for the reception of the large peduncle of the uropoda. The telson has the characteristic structure of members of this genus. The proximal pair of transverse sutures are sinuate; the distal pair of sutures are oblique.

The antennulae lie beneath the rostrum and have the basal article very large, produced on its inner distal angle into a rounded lobe which encups the base of the next article; the remainder of the anterior margin and external distal angle is rounded, produced and serrated by six large sharp teeth while a semirosette of small teeth crest the external angle; the outer surface of this article has several transverse rugae one of which completely crosses it; the free joints of the antennules are small, slender, folding upon each other and fitting beneath the basal article.

The external antennae have the basal article short and produced on its anterior distal margin into a serrate comb-like process. The second joint is cylindrical, about a third longer than the first and fringed on its distal margin with fine setae; the third joint is small and convex, the flagellum is 22 mm. long and is composed of numerous fine annulations.

The external maxillipeds have the proximal joint small with its anterior margin subcrescentic, produced to a sharp point at the inner distal angle; the next joint is minute, triangulate; the third joint is broadly rounded and produced on its inner distal margin and has several transverse squamose rugae on

its outer surface; the fourth segment is small, subtriangular with its inner distal angle produced to a sharp tooth and its distal margin sinuate; the fifth segment is slightly longer than the fourth and has its inner lateral margins separated by a channel around which these margins are curiously produced. The sixth segment is rhomboidal; the seventh is a narrow, long triangle; these two segments are obliquely flattened and their inner lateral margins bear long, curved brushes of fine plumose setae; similar brushes are borne on the inner lateral margin of each of the fifth and fourth segments, while the single inner margin of the remaining segments is fringed with similar plumose setae.

The chelipeds are subequal but both are well developed, rather thick and strong, but decidedly flattened; the proximal joints are short; the merus is short, trigonal, covered with squamose rugae on its outer and upper surfaces, its inner distal angle produced to a prominent tooth and with a longitudinal series of three raised dentiform squamae accentuating the posterior lateral border; the carpus is long and narrow covered with irregular rows of squamae and with the anterior border armed with three large serrated teeth and several small ones; the posterior lateral margin bears a row of about ten raised, dentiform squamae in addition to the distal tooth; the propodus is twice as long as the carpus and has its lower border decidedly convex, its upper border forming the two sides of a broad triangle; the fingers comprise five-twelfths of the length of the entire propodus. The fingers are of equal length but the upper finger is approximately one-third wider at the base than the lower; each finger has the cutting edge straight, the proximal half smooth, the distal half is marked into low, close-set obtuse teeth, the apices of the fingers are distinctly curved; the upper margin of the hinged finger is carina-like; both fingers are covered with squamae, like those on the palm.

The first, second and third ambulatory legs are subequal; each has the merus greatly enlarged, its maximum width being three-fifths of its length, with the anterior margin set with a row of acute spines, the upper surface is covered with small squamae, the posterior margin is reinforced with a row of coarse raised squamae; the carpus and propodus taken together are almost as long as the merus but are conspicuously narrower and with less prominent squamae; the dactyl is not quite half as long as the propodus and is decidedly curved and acuminate apically. The merus, especially along the anterior margins bears numerous plumose setae; the distal three joints bear similar shorter plumose setae and also many long, stiff spinose setae.

These three pairs of legs are alternately banded with red and white on the distal three joints. The fifth legs are typically reflexed, long and slender and weakly subchelate.

Petrolisthes amoenus (Guerin).

Porcellana amoena Guerin, in La Sagra's Political and Physical History of Cuba, vol. 8, Atlas, pl. 2, fig. 2, 1855 and text, vol. 8, 1857.

Petrolisthes? amoenus Benedict, Bull. U. S. Fish. Comm. vol. 20, pt. 2, p. 135, pl. 3, fig. 3, 1901.

Fig 11 *Petrolisthes amoenus* (Guerin) ×3 Small adult

Diagnostic Characters.—Carpus of chelipeds five-sevenths as long as wide; or the carpus is three-fifths as wide including teeth as it is long; dorsal surface crossed by a series of prominent, oblique rugae; the posterior lateral margin is accentuated by a longitudinal series of eight rugae, which are produced into acute forward-pointing spines; the anterior lateral margin is cut into six large serrate teeth, each of which has the margins denticulate; the distal carpal margin is sinuate forming two rounded scallops between the two distal teeth. Carapace but little convex, the lateral margin delineated by a sharp line which terminates anteriorly in a sharp hepatic spine; a second similar spine occurs a little above the lateral line and almost as far behind the hepatic spine as the latter is from the postorbital spine. The entire surface of carapace is covered by strong, unbroken, transverse rugae which are equally prominent on the anterior, median and posterior regions of the carapace. Distal pair of sutures of the telson oblique.

Type.—Collected in Cuba and deposited in the Habana Museum.

Galapagos Distribution.—Off Hood Island, Station 54.

General Distribution.—Known from Porto Rico; Cuba (type-locality) and the Galapagos Islands.

Material Examined.—Two specimens from station 54, Gardner Bay, off Hood Island, Galapagos.

Technical Description.—Carapace 4 mm. long; 3.5 mm. wide, but little convex; lateral margin delineated by a sharp line which terminates anteriorly in a sharp hepatic spine, a second similar spine occurs a little above the lateral line and almost as far behind the hepatic spine as the latter is from the postorbital spine. The rostrum is broadly triangulate with the median lobe rounded

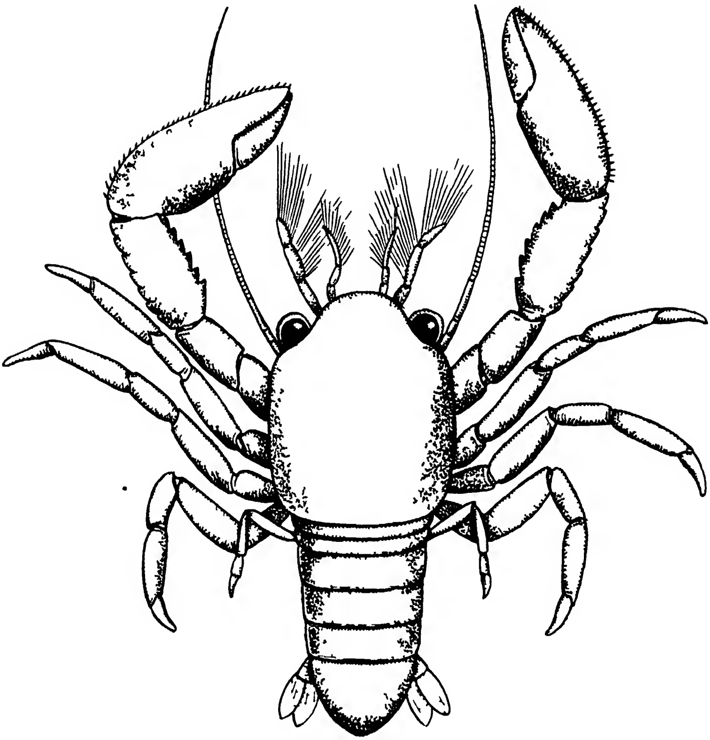

Fig 12 *Petrolisthes amoenus* (Guérin) ×10 Megalops

on either side of which the lateral margin is very shallowly excavate; the lateral angle is obtuse and deflexed. The superior orbital margin terminates anteriorly in a sharp spine and V-shaped sinus which separate it from the rostral margin; the postorbital angle forms an acute tooth. There is a wide median longitudinal groove on the rostrum extending backward to the gastric region; two smaller shorter grooves occur at the base of the preorbital spine. The cervical grooves are deep forming a wide V; behind this on the cardiac region there are two diagonal lines which run forward and outward almost to the lateral margin where they unite with a transverse line forming a figure somewhat like a pagoda roof. The entire surface of the carapace is covered by strong, unbroken transverse rugae which are equally prominent on the anterior, median and posterior regions of the carapace. The most anterior rugae form a pair of raised submedian ridges.

The abdomen has the proximal pair of sutures in the telson transverse, almost in a line with the inner distal angle of the peduncle of the uropoda; the distal pair of sutures is decidedly oblique extending inward to the apex of the central triangular plate of the telson.

The eyestalk is extremely short and is produced in the center of its distal dorsal margin to a short triangulate lobe which scarcely reaches to midway the cornea; the cornea is very large, elliptical, composed of many well developed hexagonal facets.

The inner antennae have the basal article enlarged with its anterior or distal margin serrate, consisting of four sharp teeth, the outer of which fits closely against the eye; the remaining articles are cylindrical and fold upon each other within the fossett; the flagellum is furnished with a well-developed brush.

The external antennae are longer than the cheliped; they have the basal article short and produced on its anterior margin in a large forward-pointing triangulate tooth; the second article is longer, cylindrical; the third article is half the size of the second; the flagellum consists of many short rings each of which bears a few short bristles on its distal margin.

The external maxilliped has the ischium of the endognath broadly rounded and crenulate on its distal margin and somewhat produced at the outer lateral angle; the external face is crossed by a series of deep transverse rugae; the merus is almost as long as the ischium and has the external face of the inner lateral margin produced to a slender, acute triangle the apex of which reaches to quite midway the border of the ischium; the palp is well developed, triarticulate; the long setae forming brushes on the respective joints of the maxilliped are unusually plumose.

The chelipeds are subequal. Each has the short trigonal merus crossed by transverse rugae on the upper surface and produced to an acute tooth at the inner distal dorsal angle; the carpus is 2.5 mm. long and 1.5 mm. wide, including teeth, or it is five-sevenths as long as the carapace is wide; the carpus has the posterior lateral margin accentuated by a longitudinal series of eight rugae which are produced into acute forward pointing spines; the anterior lateral margin is cut into six large serrate teeth, each of which has the margins denticulate; the distal carpal margin is sinuate forming two rounded scallops between the two distal teeth; the dorsal surface of the carpus is crossed by a series of prominent oblique rugae; the chelipeds are each 6 mm. long, with the external face very flat and crossed by a series of prominent oblique rugae; the inferior lateral margin is moderately convex and augmented with a series of small spines which are developed from the end of the rugae; the superior margin of the palm is accentuated by a carina which is made up of the edges of the series of rugae which obliquely traverse the inner face of the propodus. The superior margin of the hinged finger is similarly developed and converges distally, the tips of both fingers being curved and fitting closely upon each other. The fingers are subequal; their cutting edges straight except at the curved tips. There is no pilosity on the inner surface of the cutting edge.

The first, second and third pairs of ambulatories are similar but decrease slightly in length in the order named. Each leg has the merus about as long and wide as the carpus of the cheliped; the merus has its dorsal surface crossed by a series of transverse rugae; each ruga terminating at each lateral margin in a sharp small spine; the lateral margins are convergent both proximally and distally. There is a strong subdistal tooth at the posterior distal lateral angles

of the merus of both the first and second legs; none on the merus of the third leg; the carpus and propodus are much slenderer than the merus, compressed cylindrical, tapering; the carpus is about half as long as the merus; the propodus is two-thirds as long as the merus; the dactyl is strong, curved, acuminate. The merus, carpus, propodus and dactyl are sparsely set with long setae.

The fifth pair of legs are typically small, slender and reflexed. The brush on the propodus is composed of unusually wiry, plumose setae.

Petrolisthes galathinus (Bosc).

Porcellana galathina L. A. G. Bosc (not Say), Hist. Nat. Crust. vol. I, p. 233, pl. 6, fig. 2, 1802.

Porcellana sexspinosa L. R. Gibbes, Proc. Amer. Assoc. Adv. Sci., vol. 3, p. 190, 1850.

Porcellana boscii J. D. Dana, U. S. Explor. Exped., vol. 13, pt. 1, p. 421, pl. 26, fig 11, 1852.

Porcellana danae L. R. Gibbes, Proc. Elliott Soc. Nat. Hist., vol. 1, p. 11, 1857.

Porcellana egregia Guerin-Meneville, Crust., in La Sagra's Polit. and Physic. Hist. of Cuba, p. 39, pl. 2, fig. 1, 1857.

Petrolisthes brasiliensis S. I. Smith, Trans. Conn. Acad. Arts and Sci. vol. 2, p. 38, 1869.

Petrolisthes galathinus A. E. Ortmann, Zool. Jahrb. Syst. vol. 10, p. 283, 1897.—C. Moreira, Arch. Mus. Nac. Brazil, vol. 11, p. 93, 1901.- A. Milne-Edwards and Bouvier, Mem. Mus. Comp. Zool., vol. 47, p. 289, pl. 1, figs. 1, 2, 1923. Rathbun, Rapport betreffende een voorloopig onderzoek naar den toestand van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, pt. 1920, p. 327.—Schmitt, W. L., Bijdragen tot de Dierkunde, Afl. 23, p. 73, 1924.—Boone, Bull. Vanderbilt Marine Mus., vol. III, p. 76, pl. 20, 1930.

Petrolisthes sexspinosus Benedict, Bull. U. S. Fish. Comm. vol. 20, pt. 2, p. 133, 1901.

Diagnostic Characters.—Carpus of chelipeds .6 as long as the carapace is wide, or the carpus is two-thirds as wide including teeth, as it is long; a series of about six prominent rounded squamae form a median ridge on the dorsal surface; smaller granules are scattered on the remaining dorsal area; the posterior lateral margin is accentuated by a series of about six rugae which are produced into upward and forward-pointing spines, the distal one of which projects beyond the margin; the anterior lateral margin is cut into five acute jagged triangular teeth which have their margins finely serrate.

Carapace convex in both directions; lateral margins delineated by a line which terminates anteriorly in a single, sharp hepatic spine. Dorsal surface of carapace devoid of rugae except for a pair of wide transverse rugae on the anterior part of the gastric region; minutely sparsely granulate and finely hirsute. Distal pair of sutures on the telson oblique.

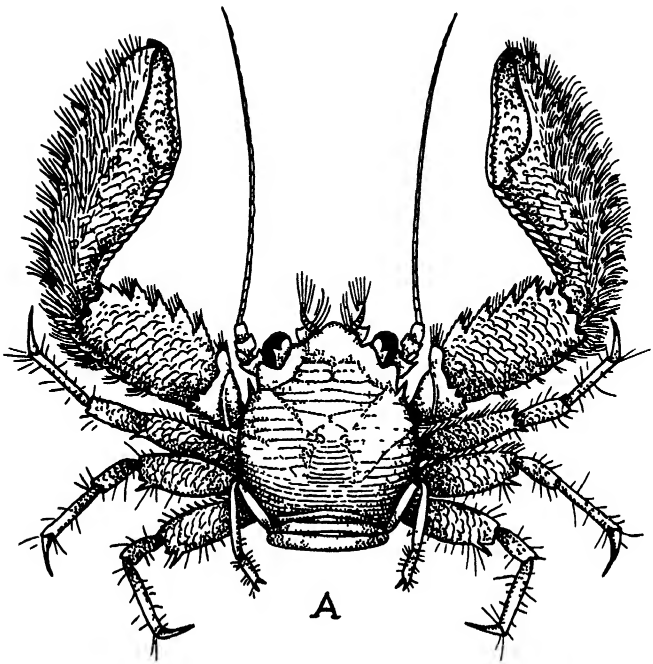

Fig 13 *Petrolisthes galathinus* (Bosc) ×3 Adult

Type.—The locality of Bosc's type was unknown.

Galapagos Distribution.—*Arcturus* station 54, off Hood Island, in 2½ fms.

General Distribution.—West Indian region and the subtropic west coast of the Americas.

Material Examined.—Six adults and one megalops were taken at Station 54, Gardner Bay, off Hood Island, Galapagos, in 2½ fms., by Dr. William Beebe, while diving. The specimens were concealed in the crevices of coral rock.

Technical Description.—Carapace 5 mm. long, 5 mm. wide, convex in both directions; lateral margins delineated by a line which terminates anteriorly in a sharp hepatic spine. Rostrum two-fifths as wide as the carapace; triangulate, apex produced broad, lateral margins excavate, outer angles blunt, obtuse. Superior orbital margin unbroken, postorbital angle acute. There are a pair of wide transverse rugae on the anterior part of the gastric region; the remainder of the carapace is devoid of rugae, minutely, sparsely granulate and finely hirsute; the cervical and cardiac regions are not areolated. There is a shallow depression on the rostrum.

The abdomen has the proximal pair of sutures in the telson transverse and the distal pair of sutures oblique.

The eyestalk is very short, dorsally constricted and produced on the upper

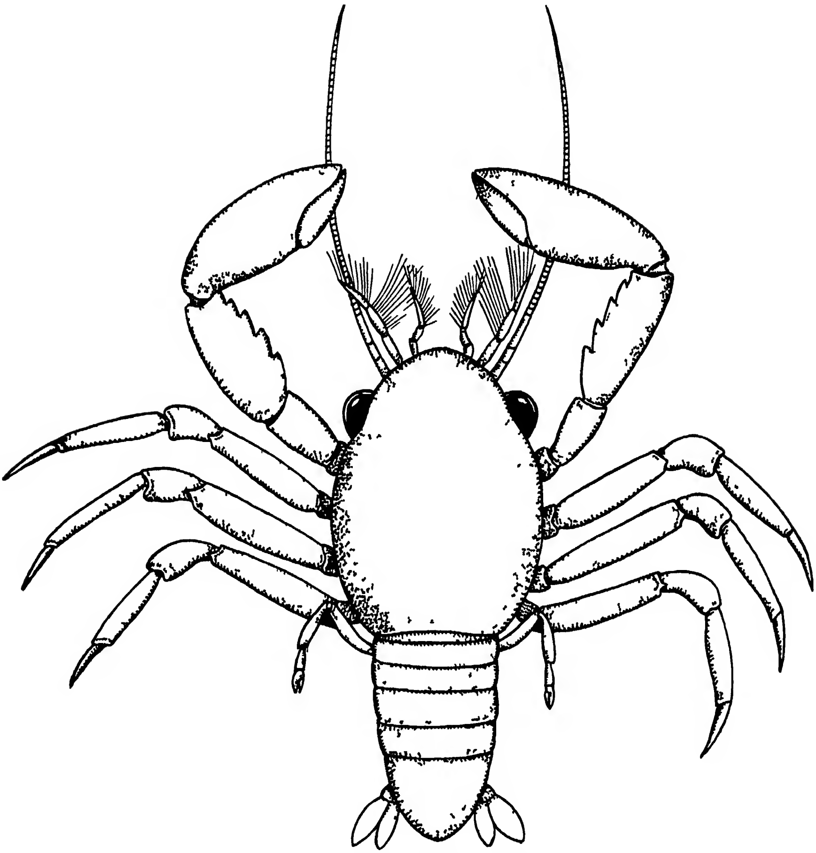

Fig 14 *Petrolisthes galathinus* (Bosc) ×10 Megalops

distal surface into an anterior rounded lobe followed by a triangular lobe which projects upon the cornea for about half its depth.

The inner antennae have the basal article greatly enlarged, lobate with the external margin traversed by rugae and the inner half of the distal margin rounded, crenulate, the apex sharp at the inner orbital angle, the outer half of the distal margin also rounded; the next two joints are slender, cylindrical and fold within the antennal fossett; the flagellum is short, two-branched, hirsute. The distal margin of the basal joint is visible in a dorsal view as a rounded lobe between two small triangulate points. This projects on each side beyond the margin of the rostrum.

The external antennae have the basal articles short, produced on its anterior, distal angle into a small dorsally concave triangulate process which has the margins finely serrate and terminates anteriorly in a prominent tooth-like apex;

the second article is slightly longer than the first and is cylindrical; the third article is about half the size of the first; the flagellum 13 mm. or 2.6 times as long as the carapace is wide, and consists of many annulations each of which is about twice as long as wide and devoid of setae.

The external maxillipeds have the ischium of the endognath broadly rounded distally and somewhat widened at the external distal angle; there is no separate lobe on the ischium at the base of the merus; the merus is produced on its inner lateral margin in an acute triangulate process which extends inward for two-thirds of the width of the ischium; the three-jointed palp is large and well furnished with long brushes of plumose setae.

The chelipeds are slightly unequal; the merus is roughened on its brief dorsal surface by a few spiny rugae and produced on its anterior distal angle into a prominent acute triangulate tooth which is subequal to those on the anterior margin of the carpus, and has its margins finely serrate; the carpus is 3 mm. long, or .6 of the width of the carapace, and is 2 mm. wide including teeth, or two-thirds as wide as long; it has its anterior lateral margin cut into five acute, jagged triangular teeth which have their margins finely serrate; the posterior lateral margin is accentuated by a series of about six rugae which are produced into upward and forward pointing spines, the distal one of which projects beyond the margin; a series of about six prominent rounded squamae form a median ridge on the dorsal surface; smaller granules are scattered on the remaining dorsal area; the distal carpal margin is sinuate; the propodus is triangulate, nearly twice as long as the carpus, decidedly flattened, with the lower margin beaded with a series of small rugae each of which is produced into an acute, outward-pointing spine; there is a prominent row of low rounded squamae extending from the upper proximal angle of the propodus to the tip of the hinged finger; the upper lateral margin of the palm is carinate and its distal angle is an acuminate tooth; the upper lateral margin of the hinged finger are subequal, close-fitting; the cutting edges concave, the tips curved. There is a sparse pilosity in the inner hiatus of the hinged finger.

The first, second and third ambulatories are subequal. Each has the merus greatly expanded, three-fifths as wide as long, or equal in width to the carpus of the cheliped, and with the lateral margins convex, convergent proximally and distally; the dorsal surface crossed by transverse rugae, sparsely setiferous; the posterior distal angle of the first and second pairs of ambulatories with a sub-distal spine; on the third pair this spine is absent; the carpus is about half as long as the merus but much slenderer; the propodus is similar to but a third longer than the carpus and has its distal lateral margins produced into rounded plates which reinforce the dactyl; the dactyl is half as long as the propodus, stout basally, with a strong curved tip; the carpus, propodus and dactyl are sparsely furnished with long stiff setae. There is a longitudinal series of small sharp spines on the ventral margins of the propodus and dactyl.

The fifth legs are typically small and slender, offering no specific characters.

Fig 15 *Petrolisthes cinctipes* (Randall) ×3.

Petrolisthes cinctipes (Randall).

Porcellana cinctipes Randall, Journ. Acad. Nat. Sci. Phila. vol. 8, p. 136, 1839.

Porcellana rupicola Stimpson, Journ. Boston Soc. Nat. Hist. vol. 6, p. 480, pl. 19, fig. 2, 1857.

Petrolisthes cinctipes Holmes, Occas. Papers Calif. Acad. Sci. vol. 7, p. 107, 1900. Rathbun, Harriman Alaska Exped. vol. 10, p. 168, 1904; Rept. Laguna Marine Lab. vol. 1, p. 102, 1912. Schmitt, Univ. Calif. Pub. Zool., vol. 23, p. 179, pl. 32, fig. 1 and text fig. 113, 1921.

Diagnostic Characters. Carpus of chelipeds two-thirds as wide as long; the proximal width being slightly greater than this average; the anterior proximal angle is produced to a rounded lobe; the lateral margins are slightly convergent distally; the dorsal surface is granulose, the granules being coarser and thicker along the posterior lateral margin where they form a submarginal ridge; there is also usually a median ridge on the proximal half of the carpus; the distal dorsal margin is trisinuate with the posterior angle much the longer. The carapace is longer than wide, slightly convex longitudinally, deeply areolated, finely granulose, and the branchial regions are finely striated transversly. The distal pair of

sutures of the telson are oblique. The external maxilliped has the inner lateral margin of the merus produced into a prominent rounded lobe.

Type.—Randall's type is said to have come from the "Sandwich Islands," and is deposited in the Philadelphia Academy of Natural Sciences.

Galapagos Distribution.—*Arcturus* station 54, off Hood Island, appears to be the first Galapagan record of this species.

General Distribution.—West coast of America from Vancouver Island, British Columbia, southward to the coasts of Lower California; also Galapagos Islands; Sandwich Islands (type locality; considered doubtful by some writers).

Material Examined.—Six specimens from *Arcturus* station 54, off Hood Island, collected by William Beebe while diving in 15 feet of water. This series of specimens contains one very large male, two large females, one of which is ovigerous, and three quite small specimens, the smallest of which probably represents the first adult moult of the megalops.

Technical Description.—Carapace 6.5 mm. long, 5.5 mm. wide; slightly convex longitudinally; deeply areolated. Rostrum triangular, slightly deflexed, with a distinct median sulcus. Carapace finely granulose and the branchial regions finely striated transversely. Lateral margins moderately convex, terminating anteriorly in an acute spinelike process. Superior orbital margin unbroken, accentuated by a submarginal depression.

Abdomen composed of six segments of which the first is shortest and narrowest; the second, third, fourth and fifth segments subequal with the lateral margins separately rounded, those of the second segment differing slightly from the succeeding ones; the sixth segment is a trifle longer than the fifth segment but has its lateral parts tapering to a narrow acuminate process; the telson is triangulate; the proximal median plate is an equilateral triangle, the lateral lobes are traversed by a pair of transverse sutures which are a little anterior to the distal margin of the peduncle of the rhipidura; a second pair of oblique sutures bisect the lateral lobes in a line with the apex of the median plate. The peduncular joint of the rhipidura is wider than long with its distal margin forming two unequal convex lobes; the inner branch is slightly longer than the outer and is oval with the end slightly wider and broadly rounded; the outer branch is similar to the inner but shorter and a trifle narrower; both are heavily fringed on the margins with long setae.

The ocular peduncle is short and stout; produced on the dorsal surface into an elongate rounded process which extends nearly to the distal margin of the cornea; the cornea is large, subspherical, composed of many well-developed hexagonal facets.

The inner antennae have the basal joint enlarged and with its outer distal face triquetral; the second and third articles are slender, cylindrical and fold within the fossett; the flagellum is biramose, the inferior branch being the shorter.

The antennae have the basal joint short, produced into a narrow laminate plate on the anterior lateral margin which forms an obtuse angle distally; the second article is at least a third longer than the first and is more cylindrical; the third article is little more than half as large as the second and is somewhat bulbous; the flagellum consists of many subequal rings each of which is furnished on its

distal lateral margins with short setae; the flagellum extends to midway the palp of the cheliped.

The external maxillipeds are large and the joints fold upon themselves; the ischium is slightly wider than long with its inner and distal margin broadly rounded; its outer lateral margin sinuous and with a small rounded laminar process at the base of the merus; the merus is as long as the ischium, is channeled on the inner lateral face and has the median lateral area of its external margin produced into a prominent rounded lobe; the inner border of the channel is ridgelike and bears a long brush of plumose setae; the palp is triarticulate; the basal joint is as long as the merus, is also channeled on the inner lateral face and has the outer face of the inner margin of the channel produced into a subtriangulate plate which has a spine at the apex and has the sides of the triangle sinuous; the inner margin of the channel is also produced into a triangle which has its apex at the proximal end of the joint and projects an acute angle at the inner distal angle of the joint; the distal half of this latter process bears a long brush of setae; the second article of the palp is two-thirds as long as the first article, and is three-fourths as wide basally as it is long; its lateral margins converge distally; the inner one supports a long plumose brush; the distal article is two-thirds as long as the preceding one and forms a small tapering triangle, which is furnished with a brush of long setae on the inner lateral margin.

The chelipeds are subequal; each has the merus short, trihedral, with a blunt, knob-like process at the anterior distal angle; the carpus is 4.5 mm. long, and 3 mm. median diameter; or two-thirds as wide as long; the proximal width is slightly greater than this ratio; the lateral margins of the dorsal surface of the carpus are slightly convergent distally; the inner proximal angle produced into a prominent rounded lobe; the dorsal surface of the carpus is granulose, the granules being coarser and thicker along the posterior lateral margin where they form a submarginal ridge; there is also a median ridge which is more prominent on the proximal half and vanishes midway the distal half of the carpus; the distal dorsal margin of the carpus is trisinuate, with the outer angle much longer than the inner; the propodus is 8 mm. long and 4.5 mm. greatest diameter (taken at base of fingers). The propodus is triangular, the inferior margin being relatively straight, the superior margin of the palm diverging distally to the base of the finger where it unites with the slightly shorter superior margin of the finger, forming the apex of the triangle; the superior margin of the finger converges distally, meeting the inferior margin of the finger. The propodal finger is slightly broader basally than the hinged finger and has its tip a little upcurved and its cutting edge slightly excavate; the hinged finger swings obliquely; its superior margin is accentuated by a subparallel depression; the inferior margin is convex, the apex is rounded and bent inward. The inner face of the cutting edge has a concave hiatus not visible on the external face; this hiatus is filled by a dense, soft, pilose brush.

The second, first and third pairs of ambulatory legs are similar and decrease in length in the order named; each has the merus about twice as long as wide, the lateral margins diverging distally, each slightly convex, the dorsal margins of the merus form rounded laminar plates; the carpus, propodus and

Fig 16 *Petrolisthes eriomerus* Stimpson ×3

dactyl taken together are about as long as the merus; each joint is successively smaller distally; the carpus and propodus are subequal in length; the propodus is armed with a spine on each of the ventral distal angles; the dactyl is about one-half as long as the propodus and is stout, curved, spine-tipped and setiferous.

The fifth pair of legs is characteristically small, slender reflexed and chelate; the merus and carpus are elongate, subequal, the carpus somewhat slenderer than the merus; the propodus is slender also; about one-half as long as the carpus; the fingers are less than one-half the length of the carpus and have their apices rounded; the distal two-thirds of the propodus and fingers is covered with brushlike setae.

Petrolisthes eriomerus Stimpson.

Petrolisthes eriomerus Stimpson, Ann. Lyc. Nat. Hist., N. Y., 10, 119. 1871; Holmes, Occas. Papers Calif. Acad. Sci., 7, 108, pl. 1, fig. 15, 1900; Schmitt, Univ. Calif. Pub. in Zool., XXIII, pp. 181, 182, fig. 144. 1924.

Diagnostic Characters.—Carpus of chelipeds one and three fourths to twice as long as wide, lateral margins parallel; inner proximal angle rounded but not produced; dorsal surface finely, irregularly granulose and minutely punctuate. The carapace has the aereolations distinct, branchial regions lightly striated transversely. The distal pair of sutures of the telson are transverse. The external maxilliped has the inner lateral margin of the merus produced to a

broad rounded lobe; the distal extremity of the ischium is rather truncated and rounded.

Type.—Professor Stimpson's type material came from Mendocino, California.

Galapagos Distribution.—One specimen (photographed) taken by the *Arcturus*, is the first Galapagos record for this species.

General Distribution.—Known from the southern part of British Columbia to Lower California, also the Galapagos Islands.

Material Examined.—One specimen from Station 54, Gardner Bay, off Hood Island, depth 15 feet.

Technical Description.—Carapace 13 mm. long, 12 mm. wide, with the frontal margin produced to a rounded triangular apex which is less strongly deflected than is that of *P. cinctipes.* The dorsal surface of the carapace is microscopially striated except in the cardiac region; the cervical and urogastic grooves are deep. There are scattered, minute, irregularly placed tubercles present on the anterior half of the carapace. The first and second abdominal segments are short and wide, and are visible dorsally; the remainder are ventral in position. The telson is small, triangulate. The distal pair of sutures are nearly transverse.

The antennae have the penduncular articles large, cylindrical, the flagellum slender, finely annulated, extending to midway the propodus of the great cheliped.

The external maxilliped has the inner lateral margin of the merus produced to a broad rounded lobe; the distal extremity of the ischium is rather truncated and rounded; the palp folds into the characteristic shield.

Chelipeds long, subequal; merus short, trigonal, with the anterior distal angle produced to a rounded lobe; the carpus is about one and three-fourths times as long as wide, with the lateral margins parallel; the inner proximal angle rounded but not produced; distal margin sinuate; the propodus is nearly twice as long as the carpus, the lower margin a little rounded the upper margin, including that of the dactyl, forming two sides of a broad triangle; the fingers comprise about two-fifths of the length of the entire propodus. The fingers are of about equal length but the hinged finger is chunky, blunt.

The second, third and fourth ambulatories are similiar; each has the meral joint much wider than any of the related joints.

The fifth pair of legs are typically reflexed, short, slender, subchelate.

Genus *Pisosoma* Stimpson, 1858.

Pisosoma aphrodita, sp. nov.

Diagnostic Characters.—Carpus of cheliped suborbicular, anterior margin tridentate; in life a broad longitudinal band of white extends down the middle of the rose-colored propodus of the chelipeds.

Type.—The type of the adult, the type megalops and 12 additional adult specimens were taken at station 54, Gardner Bay, off Hood Island by William Beebe, while diving in 15 feet of water. They are deposited in the collections of the New York Zoological Society.

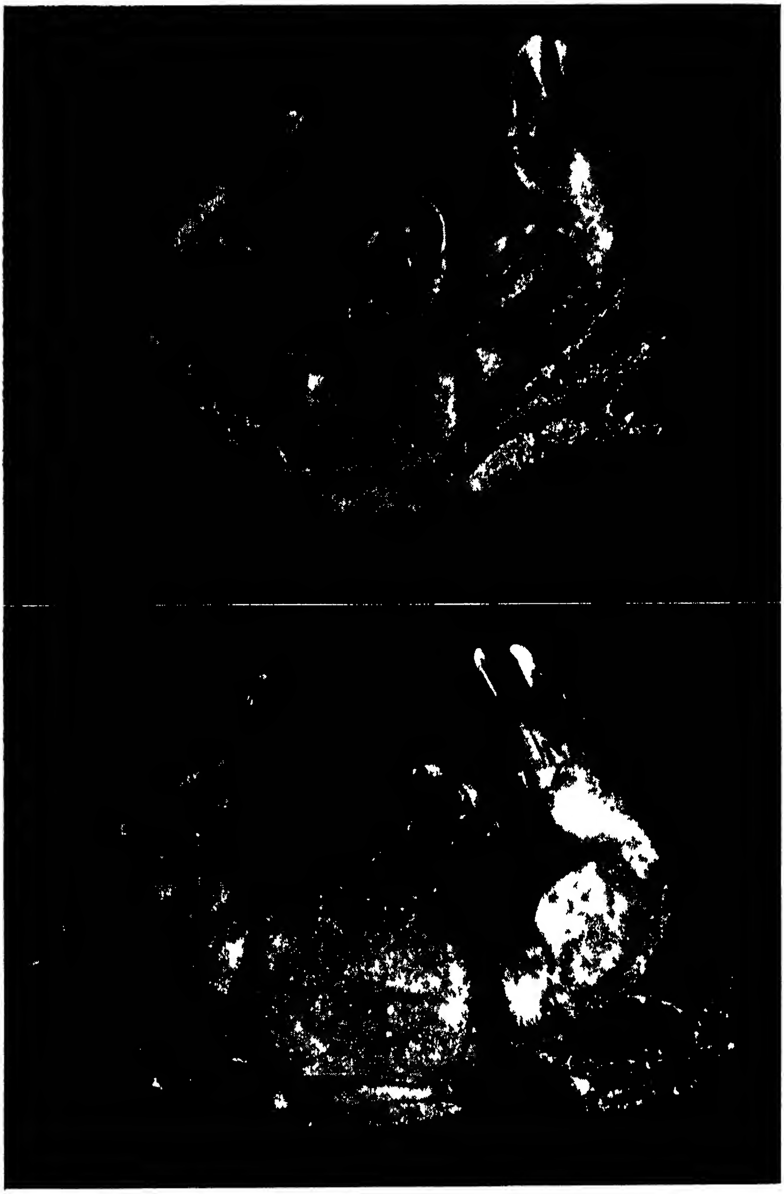

Fig 17 *Pisosoma aphrodita*, new species, type×3, A, specimen with definite three toothed carpal margin, B, specimen in which the three-toothed carpal margin is vague on the left side, and obsolete on the right

Galapagos Distribution.—Off Hood Island (type-locality).

General Distribution.—Known only from the type-locality.

Material Examined.—Thirteen adult specimens and one megalops taken at station 54, Gardner Bay, off Hood Island, Galapagos, by William Beebe while diving in 15 feet of water.

Technical Description.—Carapace 4 mm. long, 4 mm. greatest width; interorbital space more than one-third of the width of the carapace; frontal margin carinate, median point slightly in advance of the rounded preorbital angles. Superior orbital margin unbroken, linear; postorbital angle a slender acute tooth; hepatic margin slightly sinuate, lateral margins convex. Dorsal surface of the carapace covered with faint punctae which are replaced on the lateral branchial regions by vague transverse striae. Urogastric line clearly delineated; other areolations obsolete. Abdomen with the first segment very short and narrow, the second to sixth segments inclusive subequal in length; the second segment with its anterolateral margin sloping; the third to fifth segments inclusive with their lateral margins broadly rounded. The sixth segment with its lateral rounded and but shallowly excavate on the posterior side; the telson is two and one-half times as long as the preceding segment and has its lateral-distal margins broadly rounded; the central plate is triangular; the pair of sutures in the lateral plates is slightly oblique; the median suture vertical. The peduncle of the rhipidura is small, the inner blade is longer than the outer blade, both are oval and fringed with long setae, as is also the telson.

The external antennae have the basal article short, the second article twice as long, cylindrical, with a carinate line on the anterior margin; the third article half the size of the second; the flagellum is composed of many short rings, devoid of setae and extends almost to the tip of the propodal finger of the cheliped.

The inner antennae have the basal article enlarged, flattened with the distal margin broadly rounded the outer face so crossed by rugae; the remaining articles are slender, cylindrical; the flagellum is composed of two short unequal branches, the larger of which is heavily setose.

The external maxillipeds have the ischium of the endognath with the lateral margins decidedly divergent and the distal margin very convex; the merus is produced on the external face of its inner margin into a deep-wide, rounded lobe; the basal article of the palp is produced on the external face of its inner margin into a broad triangle which has the lateral edges a little convex; the second and third articles of the palp offer no specific characters; the brushes of setae are very long.

The chelipeds are conspicuously unequal in size but are similar in structure, except that the fingers of the larger cheliped are each armed with a basal tooth and are otherwise separated from each other when closed by a wide gape except at the tips which meet. The merus is trigonal, dilated distally and produced to a broad triangulate tooth at its inner distal angle; the carpus is four-fifths as wide as long, almost suborbiculate, slightly convex on the dorsal surface, a distinct submarginal ridge accentuating the convex posterior lateral margin, this ridge terminating distally in an acute tooth; the distal margin is sinuate;

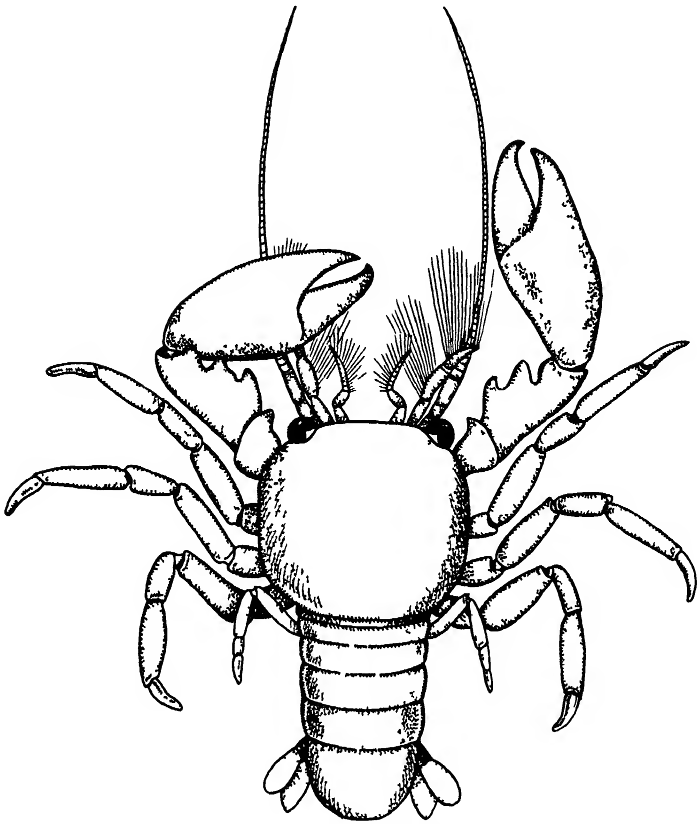

Fig 18 Megalops of *Pisosoma aphrodita*, new species ×10

the anterior lateral region is expanded into a thin plate which is cut into three rounded lobes, one of which is at the distal angle. These three rounded lobes are of varying degrees of incision. In fact one specimen (plate 20, fig. A) shows them well developed on one carpus and obsolete on its mate. The propodus is twice as long as the carpus and its maximum width (at the base of the fingers) is equal to one-half of its length; the dorsal surface is decidedly convex; the lateral margins of the palm diverge greatly distally; the lower lateral margin is paralleled by a deep longitudinal groove which extends almost to the tip of the finger; the upper margin of the hinged finger has a similar groove along the proximal half of its margin. The small cheliped is about two-thirds the size of the large one and its fingers meet along the cutting edge. The dorsal surface of the merus, carpus and propodus is finely punctate on the anterior half, becoming rougher on the posterior half, especially on the carpus where faint striae are visible.

The first, second and third ambulatories are similar in structure but successively decrease in length in the order named; each has the merus dilated; the remaining segments slender, tapering, the dactyl is very curved and acuminate. The carpus, propodus and dactyl are furnished with many long spinose setae to which are attached the various minutae used by the crab for camouflage.

The fifth legs are very small and slender, with the merus greatly elongated and bent; the carpus about half as long as the merus; the propodus about as long as the carpus; the fingers spatulate broadly, rounded distally; the distal part of the carpus and lateral and distal margins of the propodus are furnished with many long, spinose setae.

Eggs.—One of the females of this series measuring 3 mm. in diameter, carried 14 large creamy, ovoid eggs, which taxed the capacity of the brood pouch.

Megalops.—The carapace of the megalops is 1.5 mm. wide, and conforms to the general contour of the adult but is granulose and decidedly more convex; the rostrum is of similar contour but freer. The abdomen is bent downward on a wide arc; the telson is 2½ or 3 times as long as the preceding segment and is subovate, nearly circular with the distal margin produced to a point and with the outer surface slightly convex, the inner surface correspondingly concave. The rhipidura are small, subovate, subequal, not half as long as the telson and fringed with setae. The three pairs of swimming organs arise from the second, fourth and fifth segments respectively. Each appendage consists of a short, strong peduncle, a second joint which is about half as long as the abdominal segment from which it arises is wide, this joint is four-sided, the lateral margins being markedly divergent, the outer margin a little longer than the inner; both distal angles truncate, the distal margin between them excavate; the outer distal angle supports a small subovate article which is not quite as long as the width of the distal margin of the preceding article, and is scarcely one-half as wide as its own length, with the outer lateral and distal lobe of the inner lateral margin furnished with setae which are quite as long or longer than the article itself; the inner distal angle supports an article that is similar to, but only about two-thirds as large as the outer article and is devoid of long setae.

The sternal plastron is wide and concave.

The external antennae are about one-third longer than the extended cheliped.

The inner antennae are quite similar to those of the adult. However, the setae are longer and more abundant on the antennae of the megalops.

The external maxillipeds are quite long and very abundantly furnished with brushes of plumose setae which are much longer in proportion to the segments than those of the adults.

The eyestalk is minutely longer than that of the adult; the cornea is similar to that of the adult.

The cheliped (one is missing in the specimen under examination) is a miniature replica of the adult cheliped except that the three teeth of the anterior lateral margin of the carpus are more acute-tipped than those of the adult. The

inferior margin of the propodus is similarly grooved; there is no groove on the dactyl. The cheliped of the megalops is smaller in proportion to the ambulatories than is that of the adult of either sex.

The first, second and third pairs of ambulatories are similar in structure and decrease slightly in length in the order named. These legs are long, slender and finely setose. Each leg has the proximal articles well-developed, the distal part of the ischium projecting beyond the carapace in a dorsal view; the merus is elongate and dilated with the lateral margins convergent proximally and distally as in the adult form; the carpus, propodus and dactyl are long, slender, compressed cylindrical; the carpus being half as long as the merus; the propodus is quite as long as the merus; the dactyl nearly two-thirds as long as the propodus, curved, acuminate, armed on its ventral lateral margin with a series of spines.

The fifth pair of legs are small and slender, similar to those of the adult, except that those of the megalops are extended instead of being reflexed and concealed.

Color.—The color of the alcoholic-preserved adult specimen is a rich rose red on the carapace and legs; there are a pair of small circular white spots on the branchial region just posterior to the border of the hepatic region. There is also a conspicuous broad, median longitudinal band of white running from the base of the carpus to the base of the hinged finger; a much narrower, linear band of white extends from the base of the hinged finger along the cutting edge, widening distally; the tips of both the hinged and propodal fingers are white.

The smallest adult, which is but little larger than the megalops, has the same distinctive color pattern.

Habits.—This elegant little elfin crab dwells in the crevices of the coral rock bottom. It possesses the habit, so well known as a spider-crab attribute, but so far as I am aware, not heretofore ascribed to a *Porcellanid*, of dressing itself in bits of its environment. The adult representatives of the present species in every instance had their ambulatory legs heavily clothed in sponge and bryozoa; the exposed carapace and chelipeds, because of their color-pattern, would blend indistinguishably with the coral rock background.

Family HIPPIDAE

Genus *Hippa* Fabricius

Hippa denticulatifrons (Miers). Sand Bug.

Remipes testudinarius, var. *denticulatifrons* Miers, Jour. Linn. Soc. London, vol. 14, p. 318, pl. 5, fig. 2, 1878. Balss, Abh. 10, p. 92, text-fig. 50, 1914.

Remipes adactylus denticulatifrons Ortmann, Zool. Jahrb. Syst., vol. 9, p. 220, and synonymy, 1896.

Hippa denticulatifrons Rathbun, Proc. U. S. Nat. Mus. vol. 38, p. 595, 1910; Schmitt, Zoologica: N. Y. Zoological Society, Vol. V, No. 15, p. 170, 1924.

Fig 19 *Hippa denticulatifrons* (Miers) ×2

Diagnostic Characters.—Frontal margin denticulate. Lateral lobes narrower and projecting slightly beyond the median pair. Dactyli of second and third legs very strongly falcate, with the distal half very narrow and the apex acute.

Type.—Miers' type material is deposited in the British Museum. In his description of this species, which he ranked as a subspecies, he states that the variety is apparently as widespread as its Indo-Pacific congener, *H. testudinarius.*

Galapagos Distribution.—Charles Island (Miers): Conway Bay, Indefatigable Island and Eden Island (Harrison Williams Galapagos Expedition); Tower Island (Arcturus Oceanographic Expedition).

General Distribution.—Zanzibar; Philippine Islands; Masbate; Java; New Hebrides, Aneityum; Loyalty Islands; Lifu; Galapagos; Cocos Island.

Material Examined.—One male, Cocos Island, May 22, 1925; one male, one female and one very young specimen from station 37, zone H, Darwin Bay, Tower Island, taken by the *Arcturus;* one female and one male taken by the Harrison Williams Galapagos Expedition at Conway Bay, Indefatigable Island, Galapagos.

Technical Description.—Carapace 12 mm. long, 9 mm. wide; moderately convex in both directions; marked with fine, broken, transverse lines and very finely setigerous. The frontal margin is sinuous, divided into four lobes, of which the median pair are moderately developed, obtuse and rounded, the submedian or lateral pair are narrower basally and project a little beyond the level of the median pair. The frontal margin is denticulate, this normally being more pronounced in the adult. There is a small lateral submarginal band composed of striations and small tufts of hair.

The first, second, third, fourth and proximal part of the fifth abdominal segments are dorsal in position and form a convex, triangular wedge of which the remaining part of the fifth segment and the long sixth segment form the convex lower surface. The first segment has its lateral parts produced into rounded wing-like projections which are ornamented dorsally with two parallel transverse bands of short hairs, which give the lateral parts the aspect of being composed of three segments. The second segment is about as long and fits into the posterior emargination of the first segment; the lateral parts of the second segment are only a little produced and rounded, and traversed by a short median band of setae simulating two segments; the third segment is about as long but not so wide as the second and has its lateral margins rounded, not produced and with only a very short transverse line of setae on the lateral lobe; the fourth segment is about as long as the third but is more strongly vaulted and has its lateral margins acuminate; the fifth segment is mostly ventral in position, strongly vaulted, subtriangulate and about one and two thirds times as long as the fourth; the telson is about two and one third to two and one half times as long as the preceding segment and forms an elongated, arched triangle with smooth polished surface and subcarinated lateral margins which bear fine setae set upon the side of the telson. The rhipidura arise from the outer proximal border of the telson and consist of a long, arched, basal joint which is reflexed backward and upward upon the abdomen, and two ovate blades which are reflexed over and above the lateral margin of the first abdominal segment. The outer blade is narrow, fringed with long setae, and is about as long as the basal joint of the rhipidura. The inner blade is only about three fourths as long as the outer and is also relatively much broader distally. The inner blade is set upon a small, stocky basal joint which in turn arises from the large peduncular joint of the rhipidura.

The eyestalks are slender, biarticulate, gradually dilating a little distally

and being produced on the inner distal side in cuplike process around the cornea which is convex, shining black, composed of many, minute hexagonal facets. The eyestalks project slightly beyond the basal joints of the antennulae.

The antennules are coarse, biflagellate and much longer than the antennae. The first peduncular joint of the antennules is short, broad and convex dorsally with the outer lateral margin produced into a rounded, concave-convex process which curves under the dorsal part and is fringed along its margins with long setae; the second joints are slender, cylindrical and slightly longer than the first joints and support the flagella, the shorter of which consists of nine rather coarse articles, which are sparsely set with coarse setae; the longer flagellum consists of thirty short annulations, each of which is set with a few hairs on the upper distal margin. The longer flagellum is approximately twice as long as the shorter branch, and reaches almost as far forward as the anterior pair of legs when extended.

The external antennae are very coarse and reach only to about midway the short flagellum of the inner antennae. The basal joint is short, truncated distally and fitted into the lateral angle of the carapace; the second joint is longer than the first and slightly concave on the dorsal surface beneath the eye, with the outer lateral margin rounded and upcurved; the third joint is rather ventral is position curving around and encupping the short fourth joint; the third joint is fringed along its inner and distal margin with long plumose setae which form a web-like sieve; the coarse flagellum consists of three successively shorter articles, all set with bristles.

The external maxillipeds have the first and second articles small, the third large, laminar, three-fifths as wide as long, with the outer surface slightly convex and marked with series of short transverse, striae from each of which arise tufts of plumose setae. The first article of the palp is quite small, the second elongate and narrowing somewhat distally; the terminal segment is two-thirds as long as the preceding one· it is decidedly acuminate and set with several brushes of long setae. The last two articles of the palp form a sabre-like weapon.

The first pair of legs have the proximal joints strong, close-set; the merus is broad, reflexed and appressed transversely across the ventral wall of the carapace; there is a series of short transverse striae from which arise tufts of setae, on the outer surface of the merus. The carpus, propodus and dactyl are subequal, long, slender, subcylindrical articles each of which has similar striae and tufts of setae. The second and third pairs of legs are similar; they have the carpus, propodus and dactyl highly specialized. The proximal joints and merus are fittėd closely against the body, the carpus arches forward and is wider distally. Its outer lateral surface is flat and bears two longitudinal rows of setae; the anterior distal margin forms an angular elbow into which the propodus fits; the latter is short, as broad distally as its maximum width; and excavate distally on the outer face, the inner face being produced to an elongated, rounded lobe; the dactyl which is stout and falcate fits into this excavation of the propodus. The posterior margin of the finger is convex, the anterior margin, concave; both furnished with thick-set setae.

The fourth pair of legs are also robust, but differ from the second and third

pairs, in having a narrower carpus and propodus and in having the dactyl longer, narrower and acuminate with its anterior margin flattened nearly straight and its posterior margin a little concave and set with a brush of very short setae.

The fifth legs are rudimentary and are folded beneath the reflexed abdomen. They are long, slender and subchelate. The male genital appendages arise from the coxal joint of these legs. They are paired, short triangulate organs which are concave on their inner faces and convex on the outer faces.

The female appendages consist of four pairs of long, slender rod-like processes of successively decreasing length posteriorly.

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